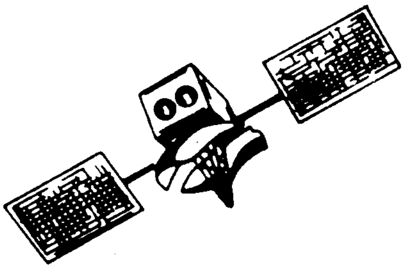
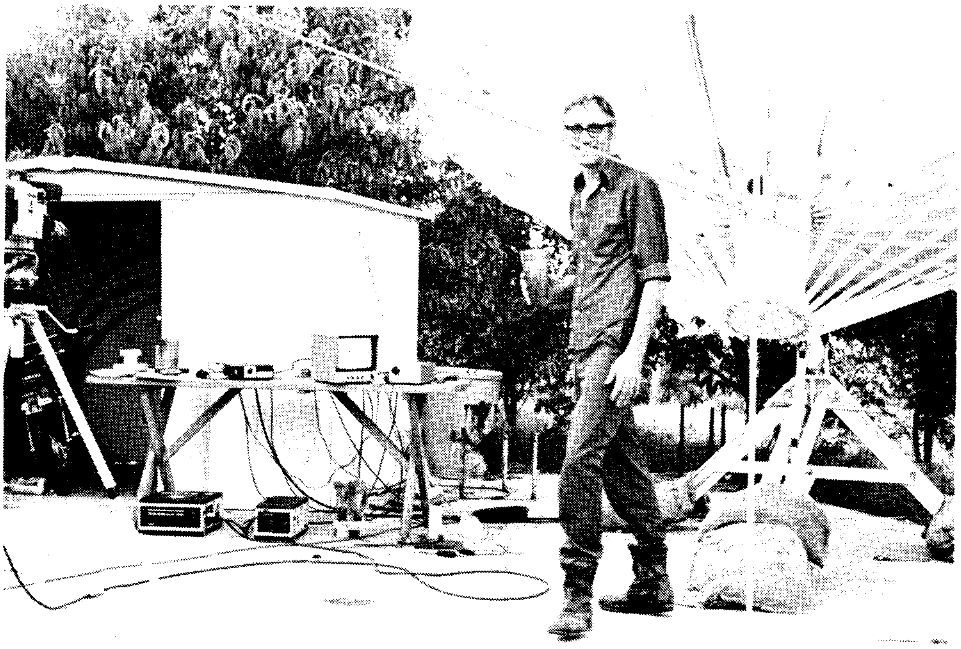


COOP'S BASIC MANUAL ON FINE TUNING PRIVATE SATELLITE TERMINALS

Copyright 1981 by:
Satellite Television
Technology
International Inc.
P. O. Box G
Arcadia, OK 73007
and Bob Cooper, Jr.



THE BASICS. The nitty gritty world of properly preparing and installing coaxial connectors, tweeking receivers for optimum performance, finding the focal point with an antenna feed and much more.

PRICE: $30 per copy

COOP'S BASIC SATELLITE TERMINAL MANUAL

GETTING optimum performance from a TVRO installation is no accident. This is a world of little things. Peak performance of a satellite terminal depends upon how well you follow the experience of others in selection and installation of your antenna, feed, LNA and all associated cables and connectors. This Manual is all about the basics. The things you must do, right, to expect peak system performance. Every time.

TOPIC **PAGE NUMBER**

NOTHING COMPLICATED HERE 3
AM vs FM / The Thin Boundary 4
FOOTPRINTS / What Do They Mean? 5
SATELLITE SPACING 7
SATELLITE OPERATIONAL CHARACTERISTICS 8
THE ANTENNA SITE 11
THE ANTENNA SURVEY 12
THE ANTENNA SURFACE 13
THE ANTENNA FEED 14
FEED POSITIONING 15
THE LNA 16
LNA / NON LNA DEGRADATIONS 18
COAX CABLE LOSS 21
LINE SPLITTERS 23
VARIATIONS / From Normal 23
AT THE RECEIVER 26
DECTECTOR VARIATIONS 27
RECEIVER FORMATS 28
RECEIVER AMPLIFICATION / Video Processing 31
AUDIO PROCESSING / The Modulator 32
THINGS YOU CANNOT DO / Expanding Coverage 33
PEAKING & TWEAKING 34
WHEN ALL ELSE FAILS 37

THIS MANUAL has been produced and is being distributed by Satellite Television Technology International, Inc., with offices near Arcadia, Oklahoma, USA. Correspondence relating to this manual should be addressed to STTI, P. O. Box G, Arcadia, Oklahoma 73007 (telephone 405/396-2574).

COPYING THIS MANUAL is a violation of the copyright of STTI. This means that any use of the material contained herein, either in whole or in part, is a no-no. This includes making single copies for friends or others who are not willing to purchase their own copy, or checking this Manual out of the local library and making copies for your own use.

CONTACTING STTI - Satellite Television Technology International is a publishing firm that produces most of the worthwhile technical and reference material in the fast growing home or private satellite terminal area. STTI also sponsors three international "seminars" each year wherein the latest products and technology in this field are displayed and discussed. STTI may be contacted at P. O. Box G, Arcadia, Oklahoma 73007 (405/396-2574). Address inquiries to Rick Schneringer. The author of this Manual is Bob Cooper, Jr., editor in chief for **West Indies Video, Ltd.**. Coop publishes the monthly private terminal industry trade publication **CSD** (Coop's Satellite Digest) which reports on worldwide developments in the satellite television field. Individual sample copies of **CSD** are available through STTI ($5 per copy US, Canada; $7.50 elsewhere). Contacting Coop directly is a bit of a problem. Letters and correspondence should be sent to him in càre of STTI. The Cooper family resides on the Island of Providenciales, in The Turks and Caicos Islands. There is no direct mail service of a reliable nature to these islands. Period. Telephone calls to Coop, from the United States, must be placed in the following manner: Ask operator for "**Overseas Operator 160 plus 105**". That will conneact you with a second operator. Tell him/her you wish to call "**Grand Turk 4273**". Be prepared for a very poor phone connection and a long wait for a line to get through. And a big telephone bill!

NOTHING COMPLICATED HERE

The mystery of satellite television service is simply that many people feel it is mysterious. Not so. In fact, comprehending how the system works, and what part each element in the system plays, is far less complicated than a similar understanding of our earth bound **terrestrial** television service.

We will in this manual concentrate on the unique simplicity of the satellite service and pay little attention to the terrestrial service; excepting where we must interface with the latter. If you come into the satellite service with some background in the terrestrial service, you may actually be at something of a dis-advantage in essential comprehension of the satellite system. This is one of those situations where **some knowledge** of one type of system simply gets in the way of understanding how a different system works.

The satellite method of delivering radio and television and data communications is superior to terrestrial systems. Arthur C. Clarke, in his 1945 thesis which forecast the development of this service, made several bold assertions. Most of these fell on deaf ears because at the time Clarke was dabbling in science fiction. For example, Clarke pointed out that one satellite could provide the same equivalent 'coverage' as thousands of terrestrial transmitters. Clarke also pointed out that for the thousands of terrestrial transmitters to function, as a **network** (i.e. carrying the **same** program at the **same** time), would require that they be somehow interconnected. He suggested that if the thousands of terrestrial stations were interconnected with coaxial cables or by microwave relay, or a combination of the two, the 'cost' of providing the interconnection system alone would be far greater than cost of a satellite. And when the cost of the thousands of terrestrial transmitters was added on top of the interconnection system, the 'savings' for a satellite system were in the 100 to 1 ratio area.

Alas, in 1945, very few people were listening to Clarke. His concept would later prove sound although some technolog had to be developed to implement his dream. To get from the 1945 dream of Arthur C. Clarke, to the reality of 1981, we have as a world been forced to take 'interim steps' to provide television services. Those interim steps, the development of alternate methods of delivering television services, have gained substantial footholds in the financial and political arenas of the world. The US television networks, for example, view the development of direct satellite reception services with considerable alarm since this 'new' technology threatens their present financial position. And this is true with virtually every part of the present television delivery system; each, such as cable television, views the development of **direct to the home** satellite television as competition to their established system. Each, naturally, would like to either stop the development of such threatened competition (before it begins), or if they are unable to do that, to pressure regulatory and legislative bodies to create rules and regulations, for the new direct to home satellite service, so that the new service is rendered non-competitive to their existing interests.

There is nothing new in this scenario of course. We all see examples of this type of 'in fighting' in our daily lives; often within our own families. Nor is there anything 'new' in the development of a maverick group of people and firms who feel the excitement and challenge of a new technology, and who want to see it grow to its fullest development level without artificial restraints.

The present 'home satellite industry' is a mixed bag of engineers, technicians and entrepreneurs. The present 'home satellite industry' is not even supposed to exist since the **present** satellite **system** was neither conceived nor designed to provide "direct-to-home' satellite service. In official circles, this is not an industry and it will not become an industry until there are new generation satellites in operation which have been designed, from the beginning, to provide direct satellite reception, and, which are **operated as** direct broadcast satellites (DBS).

Because of international agreements entered into by most of the nations of the world in the late 1960's and early 1970's, it is not "legal" for anyone to operate a satellite system in the present 3.7 to 4.2 GHz frequency band (also known as 'C' band) for **DBS**. Period. C band satellites are designed and authorized for the relay of telephone, radio, data and television programming between 'network' or 'control' points, widely separated around the earth. The 'regulators' of world communications policy adopted these rules because they saw the 3.7 to 4.2 GHz frequency band as a band of frequencies set aside for 'trunking'; or, the technique of interconnecting primary earth stations. They saw this frequency band **not as** a 'broadcasting band' intended for general reception, but rather as a 'point to point' (i.e. one specific location to another specific location) service. Arthur Clarke saw this frequency band in its most elementary format in 1945; an earth transmitting station (now we call them "uplinks") would transmit programs to the satellite, and the satellite in turn would re-transmit the program back to a segment of the earth below.

In the late 60's and early 70's, when regulatory agencies

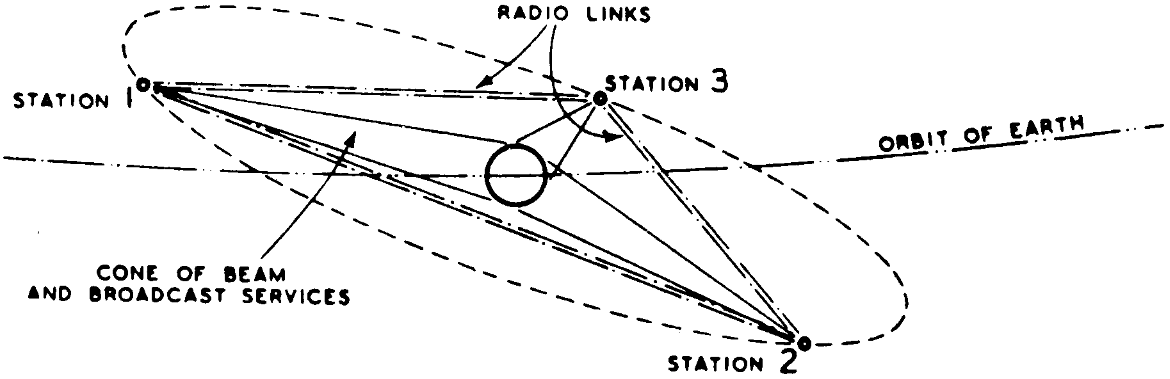
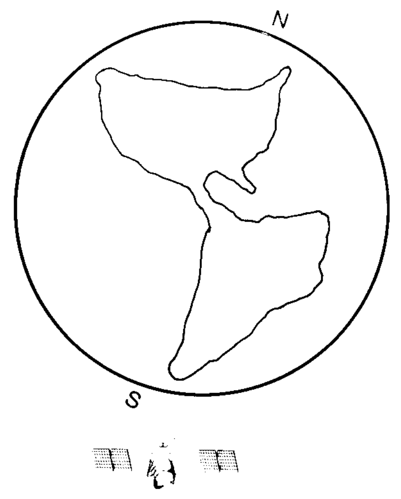


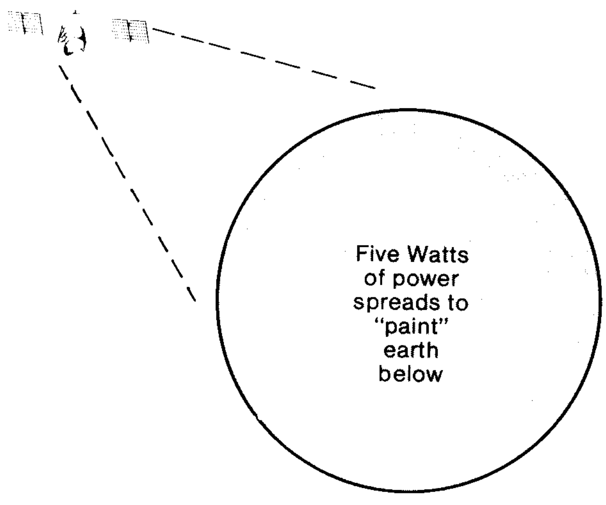
Fig. 3. Three satellite stations would ensure complete coverage of the globe.

ARTHUR C. CLARKE - originally conceived three birds covering earth; drawing from his original Wireless World article, 1945.



ONE SATELLITE CAN REACH UP TO 40% OF THE WORLD SIMULTANEOUSLY; EQUIVALENT COVERAGE WOULD REQUIRE HUNDREDS OF THOUSANDS OF TERRESTRIAL TRANSMITTERS.

THE PRECISE SIGNAL LEVEL TO BE EXPECTED FROM A 5 WATT C BAND TRANSMITTER APPROXIMATELY AT 24,000 MILES CAN BE CALCULATED.



were grappling with the problems of how to **best** utilize satellites, it was determined that the most pressing need was to interconnect **specific** widely separate **points** via satellite; such as London to New York. The theory was that both London and New York already had established 'terrestrial' (television) distribution systems in operation, and if the satellite could connect the two **points** together with the same program, then the existing terrestrial transmitters would redirect the programs **within** each local area.

And so the present C band system was created, built on paper first by asking questions and then finding answers to each question.

For example:

Question: If New York and London both require a certain grade of television signal to be delivered to their terrestrial transmitters, to maintain a specific 'quality level' in the viewer homes tuned into the terrestrial transmitter, what then must the signal 'quality' (measured as "signal to noise ratio") be going into the uplink transmitter, and coming out of the receiving terminal receiver (now called "downlink terminal" or "TVRO" in our non-industry)?

The answer to part of that question was "a 54 dB signal to noise ratio is desirable" at the downlink terminal receiver output connector. Knowing how much signal quality was required, it then became a matter of analysis to determine how they were going to achieve that 'level of service'. There were several restraints at the time; restraints created by the level of development of the satellite system technology. For example, the maximum satellite transmitter power appeared to be in the 5 watts per TV carrier region. That pretty much set or established the parameters for the balance of the 'link' system. Here is how that works:

1)To achieve a specified (54 dB signal to noise ratio or 'SNR') signal at the downlink, with 5 watts of transmitter power, some 24,000 or so miles distant, required a receiver terminal sensitivity of a specified amount.

2)There are two **major** factors which influence the sensitivity of a receive terminal; the **size** or signal-gain of the receiving antenna, and, the noise factor (or more correctly the noise **figure**) of the receiving system.

Five watts of power, connected to a transmitting antenna of known characteristics, will produce a specific and known amount of 'signal level' or 'density' on the ground at a specified point. That is all calculable. So if we know the **amount** of 'signal density' to be found on the ground in New York, for example, from a satellite 24,000 or so miles away from New York, we can then use the same type of math to determine how **large** our receiving antenna must be, and how sensitive our receiving system equipment must be, if we are going to achieve the desired 54 dB SNR.

The engineering arms of the regulatory agencies, creating the framework for the present C band system, did all of this in the late 60's and early 70's. **BUT**- they did this using the then-current level of technology. Let's see what this is all about.

Until the satellite services came along in the late 60's, there had been very little experimentation or work in this particular band of frequencies using **weak signals**. All work in **this band** of frequencies, previously, had been carried out by Bell Labs and other groups who were designing terrestrial systems that were accustomed to far **stronger** 'signal densities'. This meant that there was no body of real experience to draw upon, in terms of 'maximizing antenna gain' or 'reducing system noise figures', in **this** frequency band. So to be on the 'safe side' the early planners of the world's C band satellite systems adopted a very conservative stance or position; they would largely utilize the experience already 'known' and 'proven' from the Bell Lab type folks in designing the satellite system parameters. And, if technology came along later to **improve** the quality of their signals, well, it is better to be 'rewarded' by technology than to be 'penalized'.

It would turn out that while the 1960ish 5 watt transmitter power level for the satellite would not change materially by 1980 or so, that other factors going into the 'system link equation' (i.e. the calculation of system performance based upon known parameters) **would change**. It is the direct development of better technology in the antenna, receiver and low noise amplifier (LNA) area which has made possible in 1981 what was totally impossible in 1970; **direct home reception** on relatively small antenna systems of satellite signals in the C band intended not for home reception, but rather, for commercial 'point to point' applications.

The present home terminal industry, then, is the product of technology; it exists because the present C band satellite service system was designed around a set of 1970ish achievable parameters that were ultra conservative to begin with. And it exists because the entire satellite service system is uniquely created, on a set of engineering parameters, whereby very small improvements in receiving system performance can result in very large improvements in system sensitivity.

A THIN BOUNDARY

The terrestrial television system in use in most of the world transmits the picture using something called amplitude modulation (AM) and the sound using something called frequency modulation (FM). This was a choice made in the late 1930s after RCA and others conducted years of experiments testing AM for both picture and sound, and FM for both picture and sound. The AM picture / FM sound selection was made **at the time** because in 1937 or so it happened to work the best with the **then-current** state of technology.

An amplitude modulated television picture has a built-in limitation or two which make the transition from terrestrial television comprehension to satellite television comprehension difficult for some who understand the former. AM pictures are easily affected (or infected) by noise. Now noise can come from equipment or machinery around the receiving location, or simply from a lack of received signal strength. AM television also suffers badly in something called the 'signal to noise equation'. That means, simply, that if you have "X" amount of received signal to begin with, and the picture is filled with noise, that even if you '**double**' the amount of received signal you will still have a picture with noise. In other words, you must increase a noisy AM television picture signal level many-many times to get rid of the noise. Some examples of that are shown here.

Satellite television utilizes a (frankly) better technique; the picture and sound are frequency modulated (FM). **Why is FM better than AM?** Well, it is better only if FM is properly utilized. However, when the FM system is designed for optimum performance or something approaching optimum performance there is as a side benefit; something called "the FM advantage". In the satellite service the "FM advantage" amounts to about 37 dB or so, over a terrestrial AM system.

Perhaps the best way to illustrate this is to use some lab photographs. In **photo AM-1** we have an AM (terrestrial) television signal with a measured signal to noise ratio (SNR) of 2 dB. In **photo FM-1** the same ratio exists although here we call it a "carrier to noise ratio" (CNR). The net result is about the same in both cases; the signal strength is 2 dB greater than the noise strength. As you can plainly tell, the FM signal 'looks better' than the AM signal although neither would win any prizes for clarity.

In **photo AM-2** we have a 5 dB SNR while in **photo FM-2** we have a 5dB CNR. **Now** the difference between the two is very dramatic indeed, although the FM signal is still not high quality. Finally, in **photo AM-3** we have a SNR of 8 dB while in the **FM-3 photo** we have a CNR of 8 dB. My goodness; what a difference!

The most important thing to recognize here is that in each case we hae increased the received signal **strength** by only 6 dB; from photos AM-1 and FM-1 to AM-3 and FM-3. Another way to look at this is to state that if the satellite signal was AM picture, rather than FM picture, it would look like the photo AM-3 after a 6 dB signal increase.

If your head is spinning at this point we'll now try to put all of this into some type of better perspective. Remember, first, that our satellite is a predictable 'signal source', in the sky, roughly 24,000 miles away. And that this signal source will place in your backyard a known amount of signal level.

Now, if your **antenna** plus **LNA** plus **receiver** produces a picture that is very similar to photo FM-1, you have reached the following plateau:

1)You have found the satellite
2)You have pictures
3)And, you now know that if you can improve the sensitivity

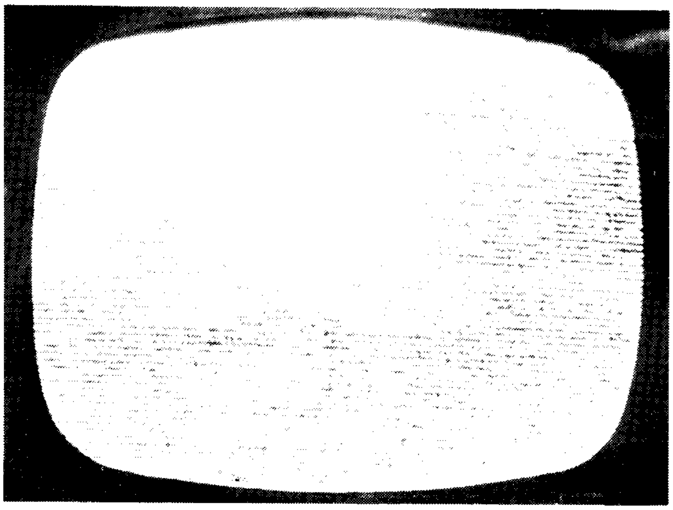


PHOTO AM-1 / 2 dB SNR with AM signal.

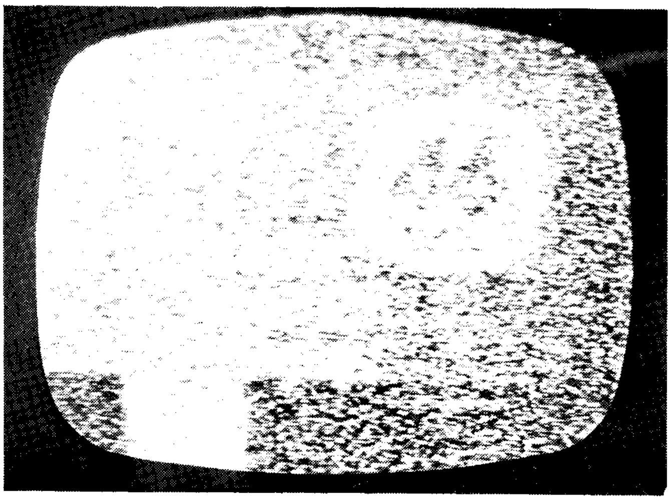


PHOTO AM-2 / 5 dB SNR with AM signal.

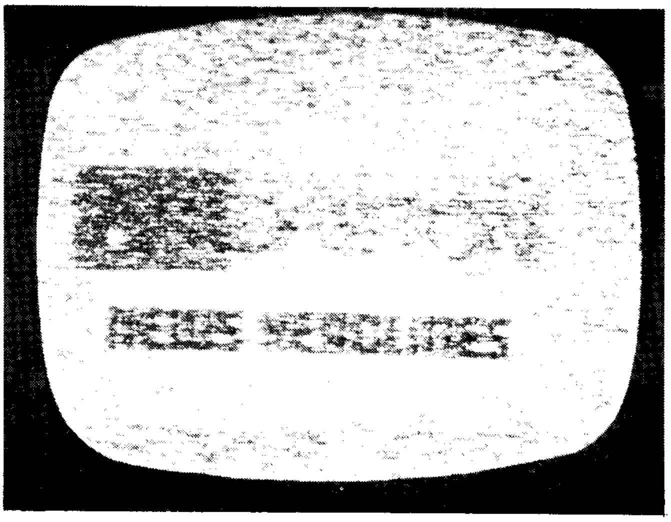


PHOTO AM-3 / 8 dB SNR with AM signal.

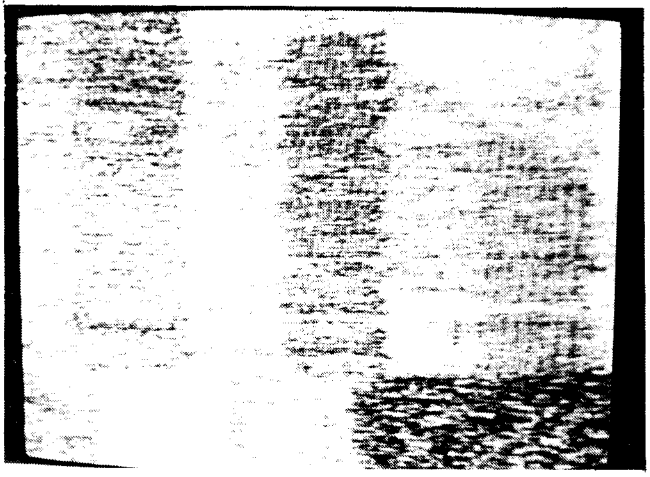


PHOTO FM-1 / 2 dB CNR with FM signal.

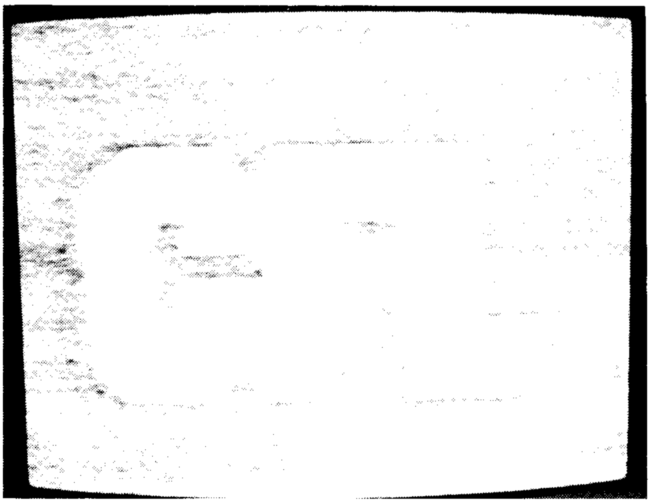


PHOTO FM-2 / 5 dB CNR with FM signal.

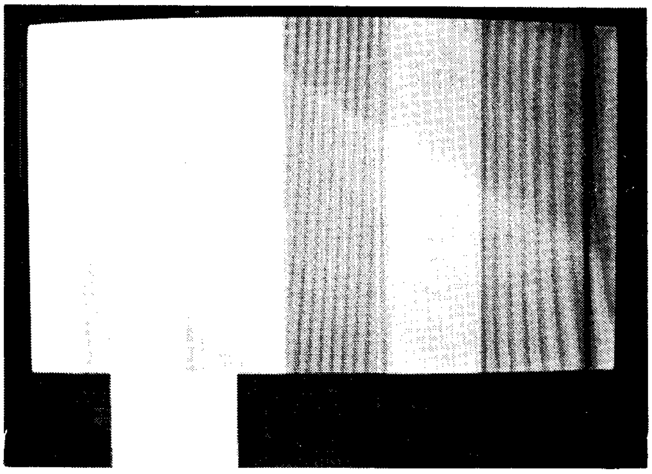


PHOTO FM-3 / 8 dB CNR with FM signal.

of your receiving system, by another 6 dB, your pictures will look like photo FM-3.

In other words, if you have **any identifiable signal at all**, you are not very far away (between 6 and 7 dB) from a perfect or nearly perfect picture. Had this been an AM television picture, you would have had to increase the system sensitivity by more than 37 dB(!) to get from photo AM-1 to photo AM-3. If 37 dB doesn't compute to you, it is the difference between a **3 inch** dish and a **10 foot** (120 inch) dish operating at our C band frequencies.

So, as you can see, satellite television reception is really the art or science of making **small** system improvements so that **every** part of the system is functioning at **top** performance level. If you have a picture that looks like photo FM-2, you are 'only' 3 dB away from "perfect" on the home receiver.

FOOTPRINTS - WHAT DO THEY MEAN?

Satellite system operators (SATCOM, ANIK, INTELSAT, etc) are all required by various regulatory agencies to provide ' 'signal coverage maps' to the licensing authority. In the satellite business, these maps are called 'footprints' since they illustrate the satellite operator's intended zones of coverage and they also illustrate the expected signal levels which the satellite will achieve.

There are three possible types of 'footprints' available to the satellite system designer.

1)**Global Beam** - This is a coverage beam which 'sees', from the satellite's location, all of the earth, within direct view, below. From a satellite altitude of 22,300 miles, the satellite can 'see' approximately 40% of the earth's surface area. Thus a Global Beam pattern is spread out, evenly one presupposes, over 40% of the earth's surface.

2)**Hemispheric Beam** - In some satellite systems, INTELSAT in particular, only a **portion** of the 40%-of-earth below is covered with signal. In theory, the satellite transmitting antennas could be so designed that the satellite could send signal only into that portion of the world north (or south) of the equator, from its vantage point, or only that portion east-of (or west-of) its location. In operation, INTELSAT employs some fixed (i.e. permanently hemispheric) and some switched (i.e. directable from the ground, on command) hemispheric beams that serve typically "east" or "west" of the satellite's location.

3)**Spot/Controlled Beam** - In most domestic (i.e. SATCOM, WESTAR, ANIK, PALAPA, etc.) satellite systems, the system designer forecasts himself into the operating longitude above the equator and creates, on paper, his desired coverage area. For example, if you were **on top of ANIK-B** at 109 degrees west, you could see virtually all of the populated regions in Canada. Since your 'mission' would be to serve Canada, and any service outside of Canada would be 'wasted coverage', you would attempt to design a transmitting antenna for ANIK-B which would 'spotlight' Canada. Typically, a 'spot beam' is shaped more or less square, or perhaps rectangular, configured so that as much of that 5 watt transmitter power as possible ends up in the parts of the earth below where the programming is intended to be utilized.

Remember that in each case the transmitter power is pretty much fixed at 5 watts (ANIK B is an exception to this, with ten watts of power on some transponders). Think of that 5 watts as 5 gallons of paint and think of the antenna as a giant paint brush. If you are going to 'paint' all of the visible earth below (40%), with that five gallons of paint, the paint will end up being very-very thin indeed. If, on the other hand, your five gallons of paint is to cover only half of the world below (hemispheric beam), the paint will be twice as thick as it would be with the full world (40% of earth) coverage requirement. Finally, if you are only going to 'paint' a single area, such as one country, the five gallons of paint will go on more thickly.

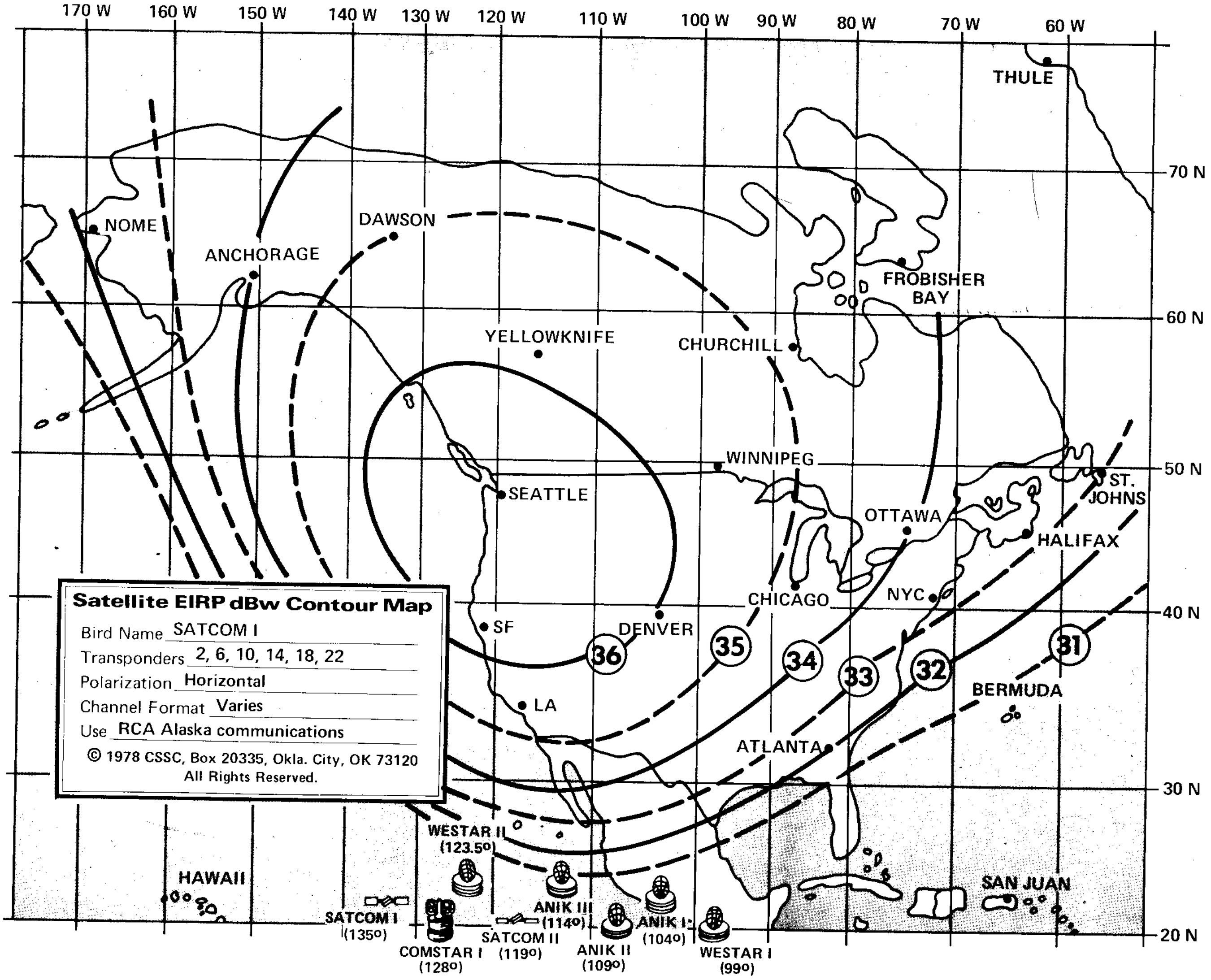
The coverage area of the satellite (i.e. Global, Hemispheric, Spot/Controlled) determines the maximum **amount of signal** level which can be expected, by the satellite operator, at the ground receiving stations. Footprint maps depict just what these signal levels are **projected** to be. **An example of such a map appears here.**

As you might suspect, signal levels from satellites transmitting on **Global Beam** patterns are the weakest of the lot (the 5 watt transmitter power being our reference for all antenna patterns) while the **Spot/Controlled Beam** patterns can be the strongest of the lot. Provided, you are located in that portion fo the globe where the Spot/Controlled beam is directed!

Global and Hemispheric beam patterns are the most predictable to work with; largely because the mechanics of the satellite transmitting antenna is considerably simpler than with Spot/Controlled beam "antenna arrays". Global and Hemispheric beams are also the most evenly distributed in terms of signal levels. A variation from the 'hottest point' within the coverage area to the 'coldest spot' in the coverage area of under 3 dB is typical for most such beams. That simply means that within a 3 dB antenna (gain) **size - region**, the same antenna system at the downlink terminal will function anyplace within the Global or Hemispheric pattern. To be more practical, a 15 foot antenna that produces a perfect picture from the INTELSAT BrasilSat feed, in Brasil, will produce just about the same picture quality in Miami, or New York, or Chile. This is an important consideration for system planners who have grown up in the North American environment, where modest changes in receiving site location often means less than modest differences in antenna receiving size requirements.

Spot/Controlled beams are strange animals. It is likely that the present family of U.S. and Canadian domestic satellites represent the 'worst we can expect' from Spot/Controlled beam satellites. That is, future generations (i.e. replacement) satellites in each of these families will do better and better jobs in **controlling** the performance of their antenna systems 'off of boresight'. **Boresight?** That's the term used to define where the **center** of the Spot/Controlled beam will land on earth. SATCOM FI, for example, draws a 'bead' on the Nebraska/Iowa/Kansas region. That's where the FI signal is **supposed to be** strongest on the ground.

Now Spot/Cotrolled beam systems start off on paper as 'Global' beam systems. A transmitting antenna must be 'forced' into a Spot or Controlled beam situation, by taking energy which would normally spray away from the satellite in all directions (i.e. Global pattern), and then focusing that energy into a desired 'pattern' or direction. This is far easier said than done.



Satellite EIRP dBw Contour Map
Bird Name SATCOM I
Transponders 2, 6, 10, 14, 18, 22
Polarization Horizontal
Channel Format Varies
Use RCA Alaska communications

© 1978 CSSC, Box 20335, Okla. City, OK 73120
All Rights Reserved.

Picture the transmitting antenna on the satellite as **a giant balloon filled with water.** The balloon seeks its own shape (Global pattern), but you want it shaped differently; perhaps like a teardrop. So you squeeze around the middle to compress the sides, and the top and bottom shoot outward since the water inside has to go someplace. After you get the teardrop configuration, you wrap some tape around the middle to hold it there, and then you decide you want the top of the teardrop to be bigger than the bottom. As you squeeze on the bottom of the giant water filled balloon, it becomes more and more complicated to hold the 'custom shape' you desire. Pretty soon you have little bumps or protrusions spread randomly over the surface; bumps you would prefer not to be there.

The satellite Spot/Controlled beam is the same way. By taking signal away from those directions, where you do not wish coverage, and forcing that signal to leave the satellite only in the direction you do wish coverage, you are increasing the amount of signal that the desired region(s) receive. **However** - in the process of doing this, in a hostile environment (space), you also get some surprises; signal 'pops out' at some unpredictable points along the way.

All of the ANIK series satellites are an example of this. ANIK-B has a useable signal level all the way down the **eastern** seaboard of the US and into the Caribbean. Yet along the **western** coast of the US, the ANIK-B signal is not strong. It is stronger in Miami (1100 miles south of Canada) than it is in San Francisco (700 miles south of Canada). In the process of squeezing in on their 'balloon', ANIK-B designers created a substantial coverage zone far to the south and east of their intended 'target' or 'boresight' region.

All US and Canadian satellites are using Spot/Controlled beams. Each of these satellites has a degree of unpredictability associated with coverage outside of their intended coverage areas, and in the case of SATCOM FI, even along the inner edges of their intended coverage area. This translates to practical field problems for anyone who will be working outside of the primary boresight regions.

Generally speaking:

1) **WESTAR I, II, and III satellites:** Along the western, southern and eastern edges of the 48 continental states, their signals fall into a 30-31 dBw contour region; which translates to a 13 foot size antenna with modern electronics. To the north, the signals hold up well ito the southern half of Canada. Outside of the US, to the south and southeast, their signals drop by roughly 1 dB for each 250 miles to the south and by 1 dB for every 400 miles to the east. Useable signals on WESTAR I (only) are found as far east as Barbados.

2) **SATCOM FI, FII satellites:** RCA satellites utilize four separate transmitting antennas for C band, with 6 transponders (channels) grouped on each antenna system. In theory, each antenna system can have a distinct boresight, although RCA attempts to maintain similar boresights, on each, on the FI bird. Because of the use of four separate transmitting antennas, there are signal-pattern-groups easily recognized in the field. Remember the big balloon filled with water? RCA birds have this problem 'times four', and it shows. Along the southeastern edge of the US, transponders 4,8,12,16,20 and 24, plus transponders 3,7,11,15,19 and 23 are as much as **2 dB stronger** than the other two antenna 'sets' (2,6,10,14,18, 22, and, 1,5,9,13,17, and 21). The two stronger sets tend to carry far to the southeast, however, with useable service levels as far as the islands of St. Maarten and Barbados.

3) **COMSTAR D2 satellite:** This satellite, part of the ATT/GTE operation of three operating satellites, has four separate transmitting antenna sets similar to the RCA family. However, unlike the RCA birds, the antenna patterns appear to be tightly controlled to the **continental** 48 states with rapid deterioration in signal levels to the south and east (where test measurements have been made). Any use of this satellite, more than 400 miles 'off shore' from the US proper, with antennas smaller than 20 feet in diameter is unlikely.

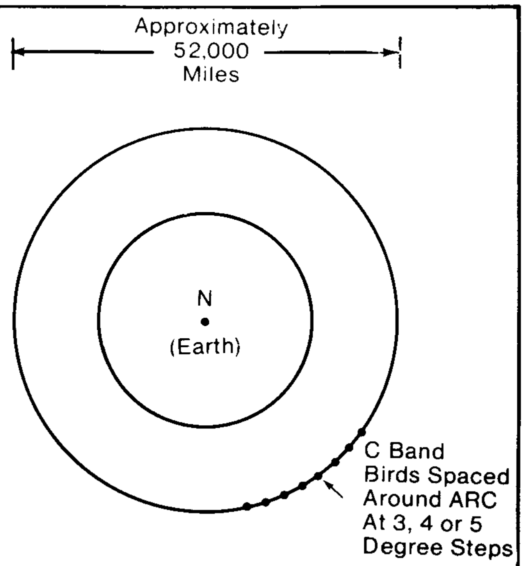
The science of controlling footprints, or signal coverage areas, is young. The present generation of satellites are pioneering birds and there is every indication that more advanced satellites in the future will have more precise control over their footprints. This suggests, quite properly, that for those users located **within** the continental 48 states (CONUS), you can expect no worse service from newer generation satellites than you presently experience from pioneering satellites. **But**, for users outside of the US, changes (probably downward by the early 1990 generation satellites) are likely.

SATELLITE SPACING

One of the earliest arguments between satellite system planners was "How close together can we place satellites along the Clarke geostationary orbit belt?". Remember that the geostationary orbit belt is directly above the earth equator, some 22,300 miles "up". Think of it as an extension of the earth that is not 7,918 miles in diameter but rather it is some 52,000 miles in diameter.

A 'circle' that large is not likely to get physically crowded. But if satellites operating in the same frequency **band** (3.7 to 4.2 GHz), and with the same frequency **assignments** within that band, and with the same polarization senses, are placed too close together, then receiving terminals on the ground begin to see interference to the desired satellite signal(s) from 'adjacent satellites'. The argument then becomes one of "How close...**without interference**?".

The conservative view, adopted in the late 60's, would have kept satellites separated by 5 degrees in space. There is no danger of them bumping into one another; that is thousands of miles apart along the arc. But at 5 degree spacing there is only 'room' for 52 satellites to operate, worldwide, spread evenly throughout the arc around the world. **Now 52 satellites seemed like a great number, in 1968 or so.** Today it seems far less than adequate, for C band birds. The US subsequently adopted a 4 degree spacing trend and there is a move afoot to settle on 3 degree spacing before it is all over.

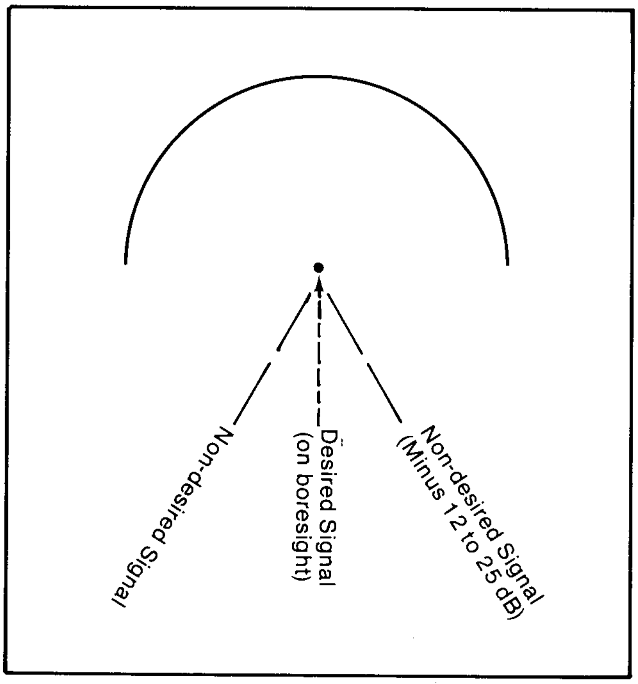


SATELLITE TO SATELLITE SPACING (ALONG OR AROUND THE CLARKE ORBIT BELT) EFFECTS INTERFERENCE FREE SERVICE ON EARTH.

The US/Canadian orbit arc segment begins at 70 degrees west and ends at 150 degrees west. Within that arc, Canada has a sub-slot of 102 through 116 degrees. To date the Canadians have chosen to maintain five degree spacing (ANIK I, recently failed, is still at 104 degrees; ANIK-B is at 109 degrees and ANIK-II and III are co-located at 114 degrees), although they do have room for five orbit spots **at 3 degree** spacing.

Ground receiving stations, and ground transmitting (uplink) stations, have antennas which have certain directional characteristics. If an uplink site, transmitting to a bird at 119 degrees, does not control its "sidelobe" radiation (i.e. signal leaving the uplink antenna 'off boresight' to the sides) properly, some of that uplink signal could wander into the receiving antenna on an adjacent satellite, at say 116 or 122 degrees. Since one of the primary advantages to satellite systems is its immunity from interference, adopting technical standards for satellite to satellite spacing which invites interference is to be avoided.

Now the larger an antenna is (in size or diameter), the more closely controlled its radiation "pattern". Since most uplink antennas are sizeable (portable uplinks aside, typically in the 10 to 30 meter class), it follows that **they** are capable of confining their uplink signals to levels and boresight accuracies which should minimize, if not eliminate, the opportunity for interference; even with 3 degree spacings between birds.


Non-desired Signal
Desired Signal (on boresight)
Non-desired Signal (Minus 12 to 25 dB)

This is not necessarily true when one looks at the directional characteristics of small(er) receiving antennas. A 10 foot dish, for example, will typically have between 18 and 25 dB of signal 'rejection' for off-boresight transmissions spaced in the sky 3 degrees **either side of** the satellite of interest. In the FM transmission service, numerous tests have been conducted to determine **how much intereference** can be 'tolerated' by various types of users, without degrading the service. Remember, not all users watch television; some small antenna system users receive digital computer data, voice circuits and the like.

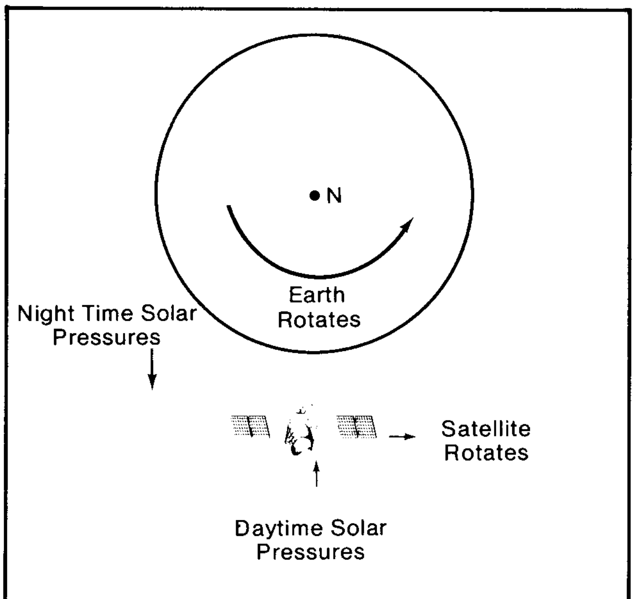
It turns out that for **television** reception purposes, interference from a second signal on the same transponder, from an adjacent satellite, must be in the 15 to 18 dB 'down' region, before it can be **detected** on the screen. Other tests suggest that if the interfering signal is at least 12 dB lower, in level, than the desired transponder signal, the 'average viewer' will not **object to** the **faint presence** of the interfering carrier.

There are several catches here however. The tests indicate that these levels of interference (-12 to -18 dB) are tolerable **provided** the two signals are both modulated with the same type of information; i.e. both television. If the satellite at 119 degrees has television on transponder 7 and the satellite at 116 degrees had data, the data could well cause some problems.

The truth of the matter is that the US FCC has not yet addressed this problem, and **for now** the 4 degree spacing will hold. It appears, however, that ten foot (and larger) antennas will continue to be adequate for **normal television reception**, even with 3 degree orbit spacing. As the demands for spectrum space grow, the pressures to allow more and more satellites into the Clarke geostationary orbit belt will build. One day, perhaps by the 1990s, three degree spacing will be with us. In the interim, US satellites will be spaced at 4 degree intervals and the Canadian satellites will either maintain their present 5 degree spacing, or also shift to 4 degree spacing.

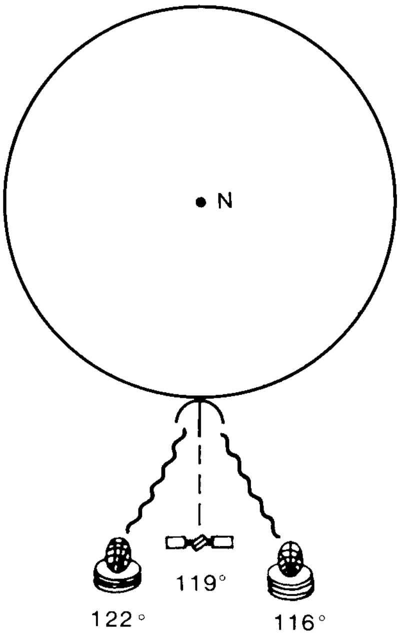
SATELLITE OPERATIONAL CHARACTERISTICS

The satellites are assigned a location (stated as so many degrees west or east longitude, with 0 degrees being the Greenwich Median) along the belt. US and Canadian satellites are supposed to maintain their assigned position within +/- .05 degree longitude (a .1 degree 'window'). This translates in actual practice, however, to a box which is roughly 70 miles on a side. The satellite operators establish 'limits' on the amount of movement they will tolerate, from a satellite, before they command it to fire miniature thruster rockets which will bring it back into the 'box'. The precise location of the satellite is determined by 'ranging' on the bird from two widely separated Icoations; such as New Jersey and California. The individual antenna readings, from both antennas involved in the ranging measurement, are sent into a computer which then solves the complex problem of **precisely where** the satellite is really located.

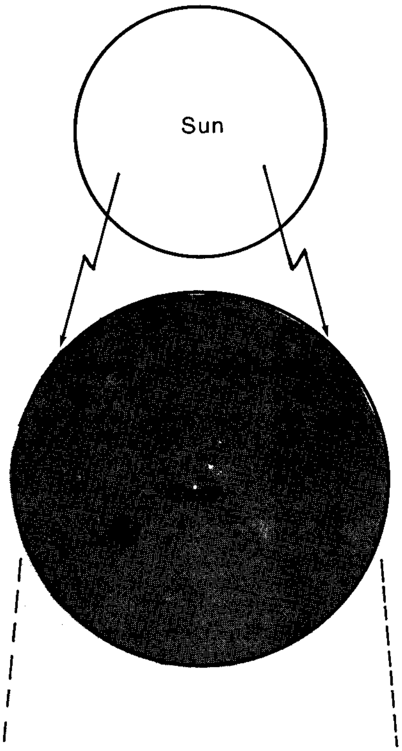


SATELLITE GEO-STATIONARY ROTATIONAL SPEED COINCIDES WITH EARTH ROTATIONAL SPEED.

Satellites 'rest' 22,300 miles above the equator because this is a special height at which their forward speed can exactly match the rotational speed of the earth. As the earth



THE UPLINK ANTENNA MUST FOCUS ITS TRANSMITTING ENERGY SO THAT ADJACENT SATELLITES (116°, 122° IN EXAMPLE) ARE NOT "ILLUMINATED".



TWO PERIODS PER YEAR, EARTH POSITION "SHADOWS" SATELLITE, CUTTING OFF SOLAR ENERGY SUPPLY. WESTAR, COMSTAR SATELLITES "POWER DOWN" TO MATCH.

rotates on its axis, the satellite flies around the earth at a companion speed. That is, of course, why the satellite appears to be 'standing still' in the sky. However, there are constant pressures on the satellites. The sun, for one stress source, is constantly bombarding the satellite with radiation. Some of it is pretty potent stuff (we don't get it on earth thanks to our lower atmosphere) and this radiation gently pushes on the satellite. When it is daylight on the side of the earth the satellite is on, the sun is behind the satellite and it pushes 'northward'. At night the sun is on the opposite side of the satellite and it pushes back to the south. This is not a precise balance however and every three or four months there is a manuevering correction required to maintain the location precisely over the equator.

Then there is the gravitational pull of the earth and the moon. **The earth's gravity is greater where there is land**, and since many of the satellites sit out over the equator west of the South America, the gravity tends to pull the North American satellites back to the east. Left alone without correction, they would end up clustered around approximately 104 degrees west one day. So the controllers monitor the location with their ranging equipment, and when the eastern edge of the 70 mile box is approaching there is a gentle rocket thruster firing maneuver that scoots the bird back to the west, to the western edge of the 70 mile box. It coasts to a stop there, and then gently begins drifting back to the east once again. This round trip sequence is repeated in approximately three to four week intervals.

Now these small changes in satellite location should not be visible to antennas smaller than approximately 15/16 feet in size. Very careful alignment of slightly larger dishes (20 feet for example) could, in theory, detect the far western edge of the box from the far eastern edge, by **slight** changes in satellite received signal levels. Certainly, alignment of antennas larger than 20 feet should take into account the location of the satellite within the box (a call to RCA or Western Union will get you this information) since alignment on either edge of the box will degrade system performance in a marginal situation for part of each month.

INTELSAT satellites take an entirely different approach to maintaining "station keeping" (i.e. satellite location). Rather than packing in the extra fuel required for frequent satellite maneuvers, the INTELSAT system equips each receive terminal with a motorized tracking system. Then they **allow** the birds to drift within a window nearly **two degrees wide**. This is roughly 20 times the "drift" tolerated by domestic birds. Even small antennas will notice this type of movement. If you happen to catch an INTELSAT bird as it approaches the drift end of its box the sudden loss of signal could well be due to the bird having been moved on you, back to the opposite side of the box. Remember that the nearest large land mass exerts the greatest gravitational pull on the bird(s); Indian Ocean birds are pulled west by Africa, for example, while Atlantic INTELSAT birds are pulled east by the same continental land mass.

Satellites obtain their operational power from the sunlight striking their solar cell arrays. The solar arrays either track the sun (SATCOM) on large wings or are used to cover the outside of the bird's surface (WESTAR). The solar rays convert to electrical (DC) energy which is stored in the birds in battery banks. At two times per year the earth falls directly between the sun and the bird and causes an eclipse. WESTAR and COMSTAR birds must shut down parts of the bird when this happens to balance the power drain with the power source available. The eclipse period lasts for approximately ten days, with varying degrees of eclipse in effect, and during those dates you will notice WESTAR I, II and III and the three COMSTAR birds **backing off** their operating transponders for up to several hours time. In some cases the power levels are reduced, while in other cases the bird goes to one or two active, operating transponders for a few hours time.

Of the present birds in operation for North America, the SATCOM birds are perhaps the most complex. This also suggests that they can have the most exotic types of failures. The most dangerous part of 'flying' a SATCOM bird are the operational maneuvers. Keeping the birds in their 70 mile box is a pretty routine thing although on a couple of occasions the birds have refused to accept the proper commands and there have been anxious moments or hours.

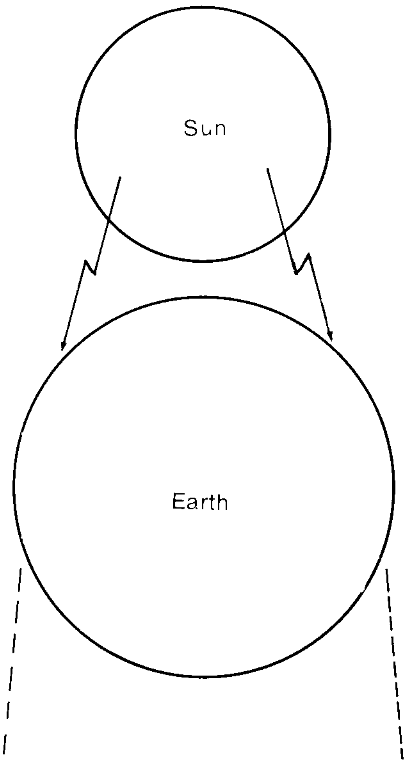
Each bird has special data and telemetry receivers and transmitters on board. They typically operate on special frequencies near the 'edges' of the 3.7 to 4.2 band; such as 3701 MHz. The birds constantly send back to the earth control stations telemetry data which reports on the operating condition of the bird. Data on the state of battery charge., the output level of the transponders, various temperatures and operational voltages flows in a constant stream to the TT&C stations. While knowing what the bird is doing is important, **having two-way contact with the bird is even more important.** One of the most difficult maneuvers in launching a bird is to get its "attention" after launch and to get it to respond to earth originated commands.

If, for example, during maneuvering, a rocket thruster should spin the satellite about so that the satellite's command system receiving antenna is pointed off into space rather than back to earth, the earth station would at that point lose all contact with and control over the bird. This happened at least once in recent years to RCA F2. Fortunately, they got control back, but it could have been a disaster.

On each bird the individual transponders have separate output power amplifiers. Of all of the component parts on a bird, the TWT (traveling wave tube) amplifiers are the most apt to fail as a class of device. Failure can be instantaneous, or it can be gradual (as in power dropping off gradually). When a TWT fails gradually, the satellite operator tries to route traffic to other transponders to nurse the TWT stage on for as long as possible. Transponder 13 on F1 is an example of this. Years ago RCA figured they would lose "on the average" **one transponders per year**. With a 24 channel bird, that means at the end of 7 years, they would have 17 left operating. F1, the oldest RCA bird, has only one totally gone transponder (4, which failed during launch, **before** it could be put into use) while 13 is ailing and 21 is **perhaps** ailing. Generally speaking, if a satellite is fully loaded (i.e. all active transponders in use) and a TWT/transponder does fail, somebody gets bumped off of the bird. Some programmers, such as HBO, own more transponders than they actually need so that they have some way to back themselves up in case of a failure.

The ANIK birds have apparently had the greatest difficulty with keeping transponders operating. Hard data is kept out of circulation but observations indicate that ANIK II and III (now flown in a single location at 114 degrees) may jointly have 12 transponders operating although singly neither would appear to have more than 8 remaining. These ANIK birds are of the same family design as WESTAR I - III and the WESTAR birds have managed to keep their early birds operating with somewhat better success. Several WESTAR I transponders are, however, operating at reduced power.

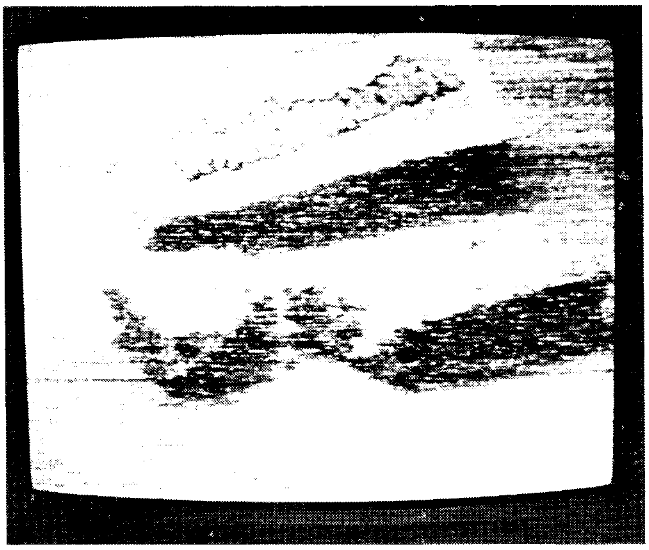
The WESTAR birds maintain their position and 'posture' in the sky by a process called 'despinning'. The shell of the satellite actually spins around while the topside antenna array rides above the spinning section and is anchored on boresight. As the satellites 'age', you can begin to **see** this spinning action. If you have a WESTAR signal that is at or slightly below threshold (i.e. threshold is where the first signs of noise begin to appear in the picture), you can see a slight 'pumping action' in the signal. This 'pump' shows up at roughly once-per-second intervals, and if your receiver is equipped with a fast tracking, accurate signal level meter you can **see** the needle **swinging** up and down as the satellite spins. The TWT stages are connected to the boresighted transmitting antennas through a device called a 'rotary joint'. This joint couples the transmitter energy to the antenna system on transmit, and connects the incoming uplink signal to the satellite receiver section on the receive side. At roughly 3600 revolutions per hour the joint was worn with time, and the imperfect contact surfaces of the worn rotary joint are beginning to show up as small 'glitches' in the received signal level.



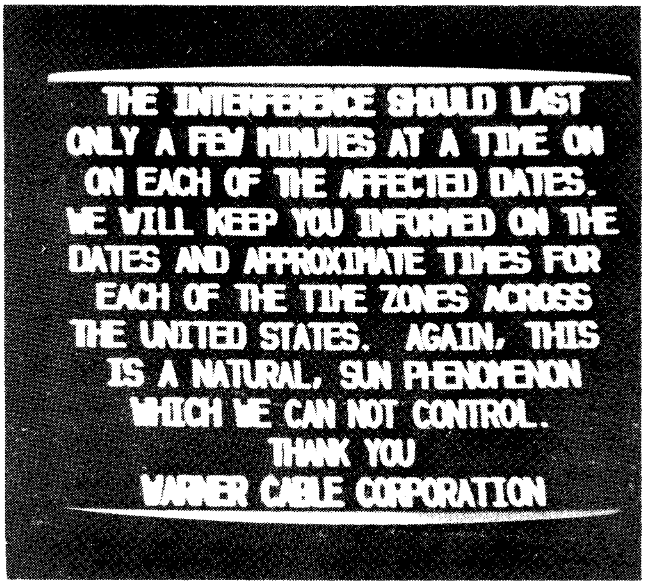
TWO PERIODS PER YEAR, EARTH POSITION "SHADOWS" SATELLITE, CUTTING OFF SOLAR ENERGY SUPPLY. WESTAR, COMSTAR SATELLITES "POWER DOWN" TO MATCH.

Finally, twice per year as the earth and the sun move through their seasonal position changes we have a situation wherein the sun ends up directly in line behind the satellite for your location. The sun emits energy over a very wide frequency spectrum; essentially from 'DC to daylight'. Some of the energy which it radiates is located across the 3.7 to 4.2 GHz frequency band. When the sun, approximately 93,000,000 miles distant, is positioned **directly behind** the satellite, your receiving antenna picks up solar radiation or noise. It appears on your screen as a considerable increase in black and white noise dots, and by some strange coincidence will almost exactly equal the strength of the 24,000 (average) mile distant satellite signal. This occurs for a time span of less than 30 minutes, usually for three to six days running, typically in mid to late afternoon for most North American observers. It begins late in September for more southern locations and gradually moves northward each day through late October. In the spring it starts in the north and moves south as the sun gradually works higher and higher in the spring sky.

This is a 'grin and bear it' situation; you cannot shut off the sun and you can't move the satellite. It lasts such a short time however it is generally considered to be a phenomenon to be observed rather than one to be excited about.



SOLAR OUTAGE - Noise from sun will completely cover up 5 watt satellite signal at peak of sun/satellite/your terminal alignment.



THE INTERFERENCE SHOULD LAST
ONLY A FEW MINUTES AT A TIME ON
ON EACH OF THE AFFECTED DATES.
WE WILL KEEP YOU INFORMED ON THE
DATES AND APPROXIMATE TIMES FOR
EACH OF THE TIME ZONES ACROSS
THE UNITED STATES. AGAIN, THIS
IS A NATURAL, SUN PHENOMENON
WHICH WE CAN NOT CONTROL.
THANK YOU
WARNER CABLE CORPORATION

WARNING - Some services (The Movie Channel here) will alert viewers to temporary nature of solar alignment.

THE ANTENNA SITE

Because the satellite is 'up there' in the sky, and, because microwave frequencies are essentially line-of-sight propagated, it follows that if we are going to intercept the satellite signal(s), we must be able to '**see**' the satellite.

Line of sight. That means that there is nothing but 'air' (or space) between your antenna and the satellite. No hills, buildings, trees or other obstructions can be in the way.

Recall that our satellite microwave signals are frightfully weak. Also recall that they are spread very evenly over large areas of earth. If there are 'holes' in the coverage of satellite signals, there has never been documentation of this. In other words, if you have 'line of sight' to the bird, and, if your receiving location is within a useable footprint region, you will find signal present. Provided:

1)There is no terrestrial microwave interference at the chosen location, and,

2)There is nothing between you and the satellite to 'block' or absorb the satellite signal(s).

Given your own location geographic coordinates (i.e. the longitude and latitude of your site), and the known fixed location in the sky of the Clarke orbit satellites, a fairly simple computer program computes for you the two factors which will allow you to 'home-in' on the satellite's location in the sky.

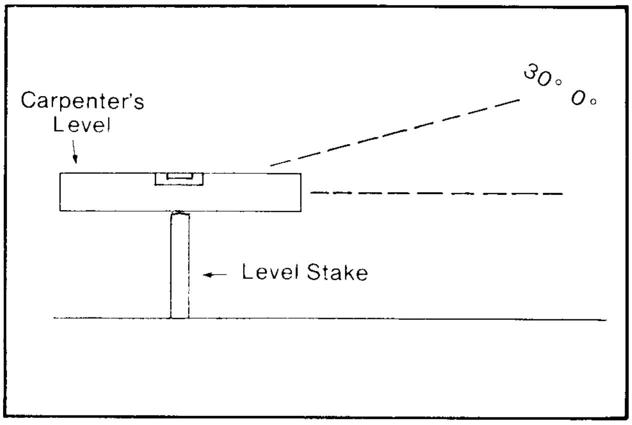
We already know the satellite is 'up'. But where 'up'? Since the equator is 'south' of the North American locations, we have a clue here. And since most of the satellites of interest are above the equator over the Pacific Ocean, we have another clue. The combination adds up to a generalized heading of 'southwest'. But that is hardly sufficient information to find a satellite.

Fortunately, the exact location can be pinpointed by having two measurement parameters:

A)Elevation
B)Azimuth

Elevation means how high up into the sky, above an imaginary line from your location straight to the horizon; assuming (for this measurement) that the earth is flat to your southwest. For example, drive a stake into the ground and using a carpenter's level insure that the stake is vertical (straight up and down). Now rest the level on top of the stake and point it southwest. Adjust the level so that it indicates that it is in fact 'level'. If you visually sight along the **top** of the level, **you are looking at "0 degrees elevation"**. If the satellite of interest is 30 degrees "elevation", it will be 30 degrees **above** your sighted line. If your carpenter's level was calibrated, so you could turn it on its axis up to 30 degrees, you could then sight along the top once again. You would be looking 'up' into the sky directly at the "**region**" where the satellite is located.

There is a small handheld device that takes much of the mystery out of this for you; it is called an "inclinometer"; a type of level that uses a pointer rather than a bubble and the pointer indicates on a scale on the inclinometer the "elevation" of the sighting tool. Inclinometers are found in general hardware stores such as the hardware department at Sears and Roebuck (Sears has a line of tools called "Angle Finders", which have magnetic bases so you can set them onto an appropriate metal antenna surface for direct antenna elevation reading).



So much for elevation. Now what about azimuth? That is your left and right (or east and west) reading. Knowing 'up' is important. Knowing "where" **to point up** is also important. Equipped with a computer derived chart of azimuth and elevation headings you have to combine the two measurements to locate the **exact** "point" in the sky where the satellite sits from your location.

Azimuth is referenced to one of two fairly easy-to-determine direction headings. The most commonly used is "true north" although the "true south" heading (the opposite of true north) is also occasionally used. The point is that you need **either** north **or** south as a "reference", since azimuth headings are given as so many degrees removed from north (0 degrees) or south (180 degrees).

This, then,is a basic **compass** exercise. First you locate true north. Now true north is **not** the same as compass north, for most of us. Compass north is the north where the magnetic north pole sits. For most people east of a line drawn on a map from central Indiana down through Georgia, true north is actually east of magnetic north, for example. This means there is a **compas correction factor** that must be taken into consideration if you are going to find true north from your yard. This subject is covered in considerable detail in STT's "**Gibson Satellite Navigator Manual**". Suffice to note here that for what follows, true north is important. You can call your loal airport to determine the **correction factor** in your area.

Having found true north you then use a simple protractor to read out azimuth in degrees removed from true north. One of the easiest ways to do this is to lay out a line in your yard that runs true north/true south. Find true north at one location (such as a few feet north of where the antenna base will set) and drive a stake to mark **that** location. Now move away from the first stake, to the south, a few feet "south of" where the antenna will sit. Find true north again and sight along a line that will take you **directly through** the more northerly stake. Drive a second stake so that if you get directly behind (to the south) of the second stake, you have the more northern stake **directly behind the southern stake** as your corrected compass reading indicates true north. A string between the two stakes wil be a true north and south line.

Now, if the computer chart tells you that your azimuth heading is 227 degrees, you can find this "angle" by laying a simple protractor under the string so that it aligns with the 0 to 180 degree line, on the protractor, with the string. In effect, 0 on the protractor is north, 180 is south. 227 then, for example, will be further on around to the southwest. If you now sight through the center mark on the protractor along the 227 degree point on the protractor (towards the southwest; you will be "northeast" with your eyeball) you'll have a heading or bearing line for azimuth to the satellite example.

It is very important, before you buy the first piece of equipment, that you determine that from your chosen satellite terminal location you will, in fact, have a "clear shot" at the satellite(s) of interest.

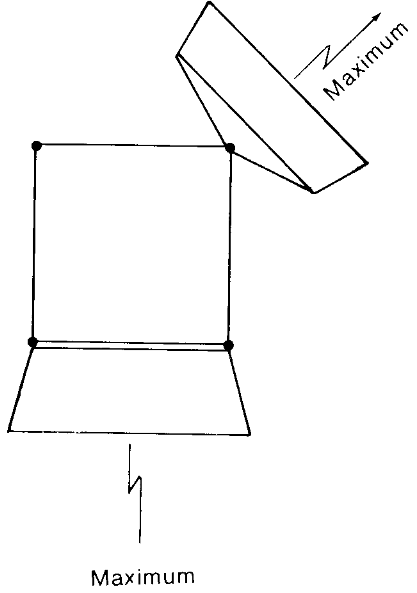
By calculating the azimuth heading, you can then go back to the inclinometer and using a stake or rod at the selected location for the terminal, elevate the sighting edge of the inclinometer until you have the corresponding "elevation angle" for the bird. Look along that line/edge. **You should see nothing but sky** if your terminal is going to have a 'shot' at the satellite. A tree loaded with foliage, the corner of a building, a neighbor's fence...anything solid or with moisture content will attenuate (weaken) or completely block your satellite signal(s).

Now remember that the satellites are in an 'arc' across your sky. Only one will be located (in our example) at 227 degrees azimuth, 30 degrees elevation. Each will have a separate set of coordinates. The further east the satellite's location (up to a point where the satellite would be due south, or 180 degrees azimuth), the higher in the sky for the bird. In fact, a bird that is **due south of you** will be your **highest elevation satellite**. East or west of due south, the closer (lower) to the earth from your vantage point. As you might suspect, the further south you are yourself, the higher in the sky the birds appear.

It may be that only some of your 'arc' is clear of obstructions. You may have a clear shot at WESTAR III, for example, but a blocked shot at SATCOM FI. Knowing this in advance of making an installation is obviously important. With an inclinometer, compass and carpenter's level you can 'survey' the orbit belt in advance and perhaps make some changes in where you plan to "plant" your in-yard terminal before you get into the equipment stage.

The other factor, which could prevent reception, is interference. Now the C band frequencies in use by the satellites are 'shared' with a terrestrial point to point microwave service, largely operated by your local telephone company. Most of the telephone connections between cities and much of the network television and radio services that criss-cross the US and Canada operate in the same band of frequencies. Because this is a point to point service, the energy from telephone company C band transmission sites is largely confined to a sharp beam that starts at the transmission site and extends to the next receiving (repeater) site.

If your proposed TVRO location is within a few miles of such an installation, you **may** have trouble with interference; even if you are not wihtin the beamwidth of the point to point antennas. Close in to such sites, transmitted energy bounces from tall buildings, trees and hills and sprays around in many directions. Fortunately, there are two things working in your favor



TERRESTRIAL "HORNS" MAXIMIZE RADIATION DIRECTLY IN FRONT OF FLAT SURFACE AREA.

1) Most such installations are in metropolitan regions. Rural (repeater) sites are usually clearly identified since their tall towers and strange looking cornucopia 'horn' antennas stand out. If the flat side of the horn doesn't point towards your location, and you are a few miles away or more, your chances for interference diminish rapidly.
2) You will be looking with your own antenna in a general southwest direction. A terrestrial microwave site north of you, for example, even if it is pointing directly at you, will probably not cause interference if you are a few miles away (or more), since your own TVRO antenna will be pointing away from the terrestrial transmitter.

There are solutions (total or nearly so) to terrestrial interference, using 'trap devices' installed in the 70 MH IF portion of your receiver. See **CSD** for July 1981, or contact Microwave Filter Company, 6743 Kinne Street, E. Syracuse, N.Y. 13057.

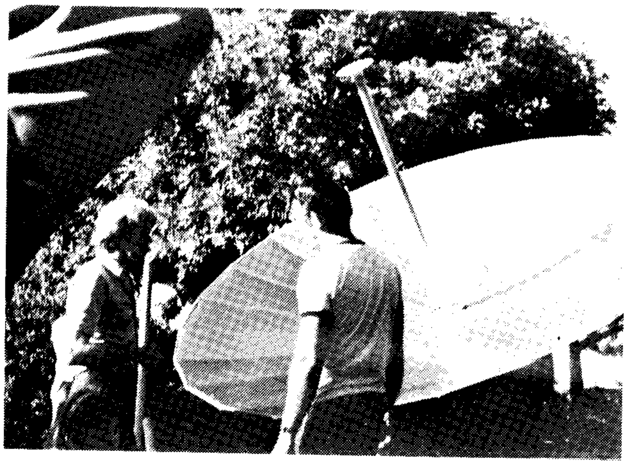
THE ANTENNA SURVEY

After thousands of commercial (CATV) and perhaps 15,000 private (home) terminal installations, a body of knowledge has been accumulated about the need for going into a proposed TVRO site and conducting a 'signal survey'. Since we know that given a clear look angle there **will be** signal there, the real purpose of a survey is either to determine whether we have terrestrial interference at the site, and/or to display (as in show off or demonstrate) the service.

There are two fairly decent ways to do this. The most popular method is to utilize a trailer mounted antenna (typically in the 8 to 12 foot size region), outfitted so that you can pull up to a site, determine your coordinate data and crank the antenna into position. Hundreds of trailer mounted rigs are now on the road, doing just this. The principal advantage to having a trailer rig is that with careful planning and experience you can have everything you need ready to go on a moment's notice. Since you will work with the rig quite frequently, it won't take you long to "get the hang of it". Pulling up to a site, and having TV pictures in 30 minutes time is no trick, after you learn how it is done.

In areas where there is terrestrial interference the trailer mounted rig can be a disadvantage, however, since often you cannot place the trailer exactly where, or close to, the permanent antenna location. One of the things we have learned, about terrestrial interference, is that by moving the antenna just a few feet (or even inches) you can often completely eliminate (or find) terrestrial interference. In other words, terrestrial problems tend to be very spotty. If the area is prone to this problem, the test antenna really needs to be almost precisely where the real antenna will later go.

One solution to this one is to utilize one of the Robert Luly & Associates Umbrella portable antenna systems. In the 12 foot size, this antenna folds up like a giant patio umbrella, and when unfolded mounts on a heavy duty camera tripod. You can place it anyplace a permanent antenna will be (including on a roof if that is the site selected). There is no one **best** choice for portable antenna rigs; there is a decision to be made however, based upon your own perceived needs.



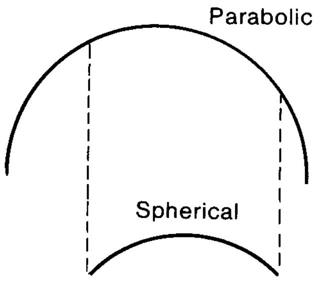
LULY UMBRELLA ANTENNA (Bob Luly, left) allows quick test location set up and alignment with easily transported package.

The bottom line on site surveying is that it is a waste of time in more than 80% of the installations; unless it is really an opportunity to demonstrate the service (as in being a selling "tool"). In that other 20%, mostly clustered in metropolitan areas, it can save you a ton of money to survey **first**, since discovering you have interference problems **after** the concrete is poured and the system installed, can be disastrous.

THE ANTENNA SURFACE

There are two types of commonly used antenna reflector surfaces in the private terminal area:

1) Parabolic
2) Spherical



SPHERICAL IS A SECTION OF PARABOLIC, ENLARGED, WHICH RESULTS IN LONG f/D RATIO.

A spherical surface is really a "section of a parabolic"; i.e., it consists of a segment of a parabolic. Both antennas function in the same manner. The reflector surface intercepts energy from the satellite(s), and re-directs the satellite signal(s) to a central focusing point. It is, in effect, a giant "mirror" to C band radio signals.

The true gain of an antenna **surface** (not **system**; we'll come to that shortly) depends totally on the precision with which the surface is formed. The parabolic (or spherical) 'curve' is adjustable, on paper, over a range of focal length to diameter ratios. This is called the antenna **f/D**. What this means is that you can taper the curve over a range of curvatures to achieve different types of antenna performance patterns.

The f/D ratio is a number. It means that the focal length (or point where the LNA plus feed antenna mount) will be some specified distance in front of the reflector surface center point. Most parabolic antennas in use in this service have f/Ds in the .3 to .5 region. This means that the **ratio** of the focal length (distance from dish center to feed) to the diameter of the dish (distance across the dish surface) will be from 30% to 50% of the diameter, i.e. a ten foot dish with a .3 f/D would have a 3 foot focal length while a .5 f/D ten footer would have a 5 foot focal length. Most spherical antennas have f/Ds in the 1.25 to 1.5 region.

Is there something magic about specific f/Ds? No. While the trade off considerations are fairly complex to unravel, the truth is that the f/D is only marginally related to the gain performance of the antenna. What does count, **more than anything else**, is the type of feed antenna. We'll see why shortly.

If there is nothing magic about a specified f/D, then what **is** important about the reflector **surface**? It's accuracy. Period.

A general rule of thumb, for C band service, is that the whole reflector surface must maintain an "**in-field-accuracy**" in the +/- 1/16th of an inch region. In other words, every individual point or spot on the surface should be within +/- 1/16th of an inch of lying precisely **on** a mathematical **parabolic curve**.

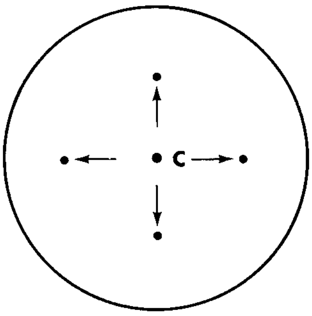
Sectionalized antennas (whether metal or fiberglass surface) go together in some type of form or pattern. When fully assembled, you have a parabola (or spherical 'section'). If the segments do not fit neatly and precisely, you will have reduced performance with the antenna as a whole. There are several clues about an antenna's parabolic (or spherical) "integrity" which you should be able to spot, as you assemble the system:

1) Wherever two sections bolt together, look **carefully** at how the bolt holes align. If they do not align, something is out of "form". If you have to ream holes to make them align to pass through the bolt, that is a warning sign.
2) If the antenna is lightweight enough that you can push and tug on the surface to "jiggle" or "force" the holes into

alignment, you are **really bending the surface** into a pattern to match up the holes rather than matching up with a parabolic curve. You may get the bolts into place, but in the process you may **also** be distorting the curve of the parabolic antenna.

3)There are some sectionalized antennas which do not follow a parabolic curve. This is difficult to tell during assembly, but it will become apparent when you mount the feed and attempt to find a focus point for the feed.

There are several ways to prove the parabolic curve. Some manufacturers provide a "proofing template"; a precut piece of metal or wood which is laid into the dish, typically bolted at the very center, and then 'spun' around the full parabolic "circle" to allow you to eyeball or measure the distance between the curved lip of the template and the surface of the dish at all points. You can prepare your own template after determining the f/D of the dish (if not known); see **CSD** for June 1981.



DISTANCE, FROM DOWEL ROD MOUNTED THROUGH CENTER AT RIGHT ANGLE TO CENTER POINT, TO EACH "SAME POINT" ON DISH SURFACE SHOULD BE EQUAL, TO WITHIN 1/16TH OF AN INCH.

Another technique is to "spot check" the surface accuracy by installing a small stiff rod, or dowel, from the center point on the dish to the focal point. Anchor the rod in place as if it were going to poke directly into the mouth of the feedhorn/LNA. Attach a swivel of some type of the outer end of the dowel, and to the swivel attach a stiff piece of wire sufficiently long to reach to the outer edge of the dish.

Now go back to the center, and using a stiff wire as a drawing compass, scribe some circles around the center at appropriate intervals (i.e. 2 feet out, 4 feet out, etc.). What you will do next is measure, from the end of the dowel rod to the circles, the **exact** distance. From the end of the dowel rod to **each** point on the dish surface scribed circle should be within 1/16th of an inch of being the same distance. Each circle will have its own distance, but **each** point on **each circle** should be the **same distance** from the center focal point.

If it turns out that you have a warped or deformed dish, correct it. This may involve loosening the bolts that hold the surface together and pushing and shoving and perhaps hole-reaming until they form a better parabolic curve fit. It may even involve scrapping the antenna and starting over.

Getting a good dish surface (accuracy) is the single most important thing you will do to obtain proper system performance. If this is not done, there is no way to make up for the deficiency elsewhere.

What about antenna gains? Virtually nobody selling in this field is equipped to conduct antenna gain tests. A handful of the larger suppliers (i.e. Prodelin, Microdyne/AFC) do have facilities that will allow them to determine to the nearest tenth of a dB the actual gain of their products. But, the gain of any **particular** antenna depends largely on the way the antenna is assembled and installed. Which gets us right back to the field assembly/proofing exercise.

THE ANTENNA FEED

The reflector surface, and its mounting system, are extremely important. Everything after this point must be designed to work at optimum performance with the particular antenna surface area.

The purpose of the feed antenna is to catch and couple energy intercepted by the dish surface into the low noise amplifier (LNA). The first feed antennas were simple 'horn' devices. They came straight out of the terrestrial microwave industry where signal strengths were high and optimum antenna performance was important but not critical.

A horn antenna, such as described in the STT "**Howard Terminal Manual**", is still a suitable antenna. But it is not an optimum antenna; that is, one designed to mate exactly with the surface of your reflector. There is extra signal gain, for your antenna **system** (i.e. including, now, the feed antenna), to be had if the feed is optimized.

The feed antenna must accomplish three things:

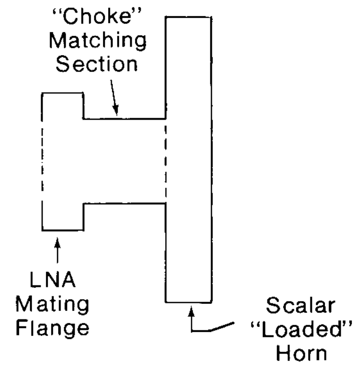
1)It must 'see' the reflector surface, uniformly, so that energy captured by the reflector surface is funneled into the LNA;

2)It must discriminate against signals coming to the feed from the ground around the reflector surface, or from the sky behind or over the edges of the reflector surface;

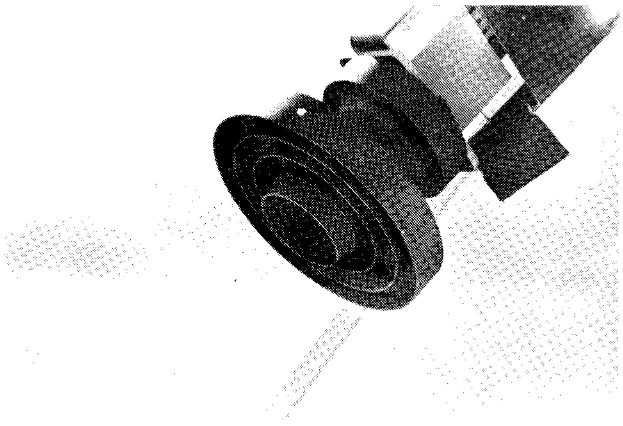
3)It must carry those captured signals into the LNA efficiently.

The most popular (i.e. best performing) feed at the moment is a variation of a design first published by English TVRO experimenter Steve Birkill in 1978. It is called a "scalar load horn". This consists of a tube or funnel that captures and funnels signal from the reflector surface to the LNA, a matching section that correctly transforms the impedance of the feed antenna to the impedance of the LNA input probe, and, a front end "loading device" that creates a receiving "pattern" for the feed antenna.

The tube or funnel is roughly analagous to the familiar horn. It is an "opening", of precise dimensions, to match or mate with the C band wavelengths. The matching section, seemingly block of metal at the rear of the feed antenna, is dimensioned to "transition" the free space C band signals into a section of waveguide and to the pickup probe on the LNA. The loading device, a series of cast or fabricated concentric circles out of some metallic material, are akin to the "director elements" on a normal "yagi" type of antenna. They help determine the directivity of the feed antenna.



POPULAR "SCALAR / HYBRID MODE" FEED ADAPTED FROM STEVE BIRKILL DESIGN ATTEMPTS TO "MATCH" WAVEGUIDE TUBE TO DISH SURFACE.



SCALAR LOADED FEED (Chaparral shown) is perhaps most popular "design" at moment, offering improved performance over standard "horn".

Feed antennas are difficult to optimize because they must "look at" a very wide field of view. The dish spreads out in front of them very widely, and ideally the feed antenna would "see"; every part of the reflector surface with "equal efficiency". The feed antenna, like your eye, suffers from **periphereal vision**; i.e. signal reflected from the **edges** of the dish arrive at the feed antenna such that they are not received **as strongly as** those that are directly in front of the feed antenna.

Feed designers attempt to compromise the best gain with the best "pattern" for the feed antenna. The pattern determines how efficient the feed is along the periphereal edges of the dish. One of the considerations is earth noise. The earth is, at C band, a source of "background noise". The reflector surface not only intercepts and redirects the satellite energy towards the feed; it also acts as a "shield" or "wall" between the feed / LNA pickup probe and the earth behind the antenna. With the proper instrumentation you can measure the quantity of earth noise present. It averages around 300 degrees (Kelvin scale). A good quality LNA has around 100 degrees of noise. Therefore, if the **full** earth noise source were to get into the feed antenna, this 300 degree noise level would literally drown out all but the strongest of satellite signals.

Some noise does "leak" around the edges of the dish and it does get to the feed antenna. This is another reason why it is desirable for the feed point antenna to have lower gain at the edges of the dish; so as to not allow the earth noise to get mixed in with the satellite signals.

Spherical antennas, because of their long f/D ratios (and to a small extent their typical open-mesh construction), are more prone to earth noise "leakage" than parabolic antennas. The exact amount of "higher noise" one can expect to find with a spherical depends upon a number of factors, including the f/D of the spherical and the design of the spherical feed antenna.

FEED POSITIONING

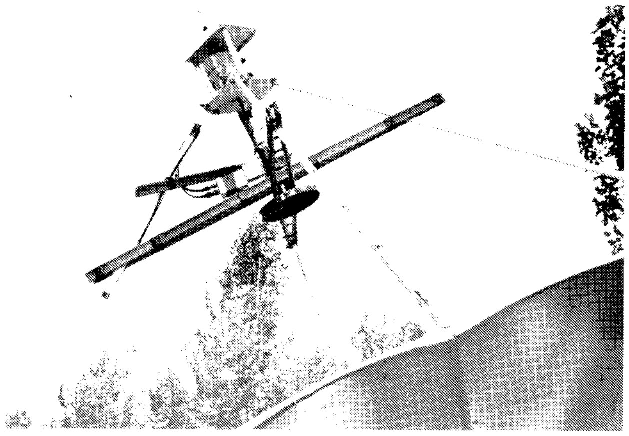
The feedpoint antenna should be located where it intercepts maximum signal from the reflector surface. If the parabolic surface is "true", this will be a point which is directly in front of the very center of the dish (at a distance equal to the f/D) and precisely centered (left and right, up and down). Most installations begin with the feed mounted at the proper calculated point and then fine adjustment proceeds from there.

Fine adjustment of the feed, while observing the signal level on a meter such as one finds on the Teknimat 692A receiver or the Washburn Earth Terminal Receiver, or by simply eyeballing a weaker transponder running a color bar test pattern, is one the of important steps to both optimizing performance of the antenna system, and, in "proofing" the parabolic integrity of the dish surface. Most feeds are mounted so they can slide in and out; that is, closer to and further from the dish surface. Clamps loosen, allowing you to move in and out the feed antenna, plus the LNA mounted (bolted) to the feed. This is generally a fairly 'broad' signal peaking exercise; movements of 1/4th inch typically result in small changes in signal level performance. If you find the signal does not want to peak, or peaks several times (peak, dip, peak, dip, etc.), this means you are either dealing with a warped antenna surface **or** a poorly designed feed antenna. Either one begs attention. There should be **one**, fairly broad, **signal peak** with the signal dropping off in both directions.

The other adjustment is centering of the feed. Some manufacturers provide a drilled hole in the center of their dish that you place your eyeball up to, from the back of the dish. If you look through this hole, you should be able to see that your feed antenna is precisely centered (the concentric circles on a scalar loaded feed make this simple to do). Other antennas have four feed support struts. The feed support struts hold the feed antenna and LNA in place, and they should be designed so as to install at 90 degree intervals around the outer edge of the reflector surface.

If you get directly behind **one** of these feed struts you should be able to **visually sight across the opposite strut member, and in the process bisect (as in cut in half, visually)** the feed antenna. Now go to the opposite 'set' of two feed struts and eyeball from one to the other, through the feed again. This will quickly tell you if your feed has the "droops", i.e. it is hanging down off of dead center in front of the dish because of a poor mechanical support system.

If the feed antenna/LNA hang down or are shoved to one side or the other because of a non-precision mounting system, you are in effect looking at a side (or bottom) of the reflector surface. This makes the opposite side of the reflector virtually useless. Unless the feed points **squarely** and evenly at the **center** of the dish, energy reflected from the full dish surface is not going to channel into the feed and to the LNA probe.



NOT PRETTY / but precise - When feed system "droops", it may be necessary to beef it up with non-metallic supports to insure proper "center alignment'

One of the simplest cures to this, assuming the dish feed mounting struts are simply poorly designed, is to obtain some 3/4 inch rigid PVC (not metal) and fashion a cross or 'X' brace assembly which will fit around the feed support system. By using clamps or cable ties you can re-center the feed using the support struts as a sighting guide. A feed that hangs down off of center can cost you a dB **or more** in signal level.

THE LNA

The Low Noise Amplifier (LNA) is fed signal directly from the feed antenna. On the back of the feed antenna is a flange, or plate, which has holes drilled in it to accept typically 3/16th inch bolts that fit through holes drilled in the flange on the LNA. The flange of the LNA attaches to the flange of the feed horn antenna and the feed antenna holes are tapped to accept the bolts.

Most LNAs have ten holes and most feeds have ten tapped holes. Numerous tests suggest that the world will **not end** if you neglect to place ten bolts (one per hole) in place. But, if you do select to use less than the full ten, be certain you use at least four; **one for each of the four sides** of the rectangle. The primary reason why you might not wish to insert bolts for **all** ten holes is that you are prone to changing out LNAs and feeds, for test or experimentation purposes. A put-it-in and walk away installation is well advised to use **all ten holes** with bolts. Furthermore:

1) If the horn supplier (or LNA supplier) provides a rubber gasket to seat into the groove that mates between the two units, use it;
2) A silicone sealing compound (available at most electronic and hardware stores), designed for moisture proofing of connections, should be run as a bead around the full four sides where the two flange plates meet (i.e. LNA flange to feed antenna flange).

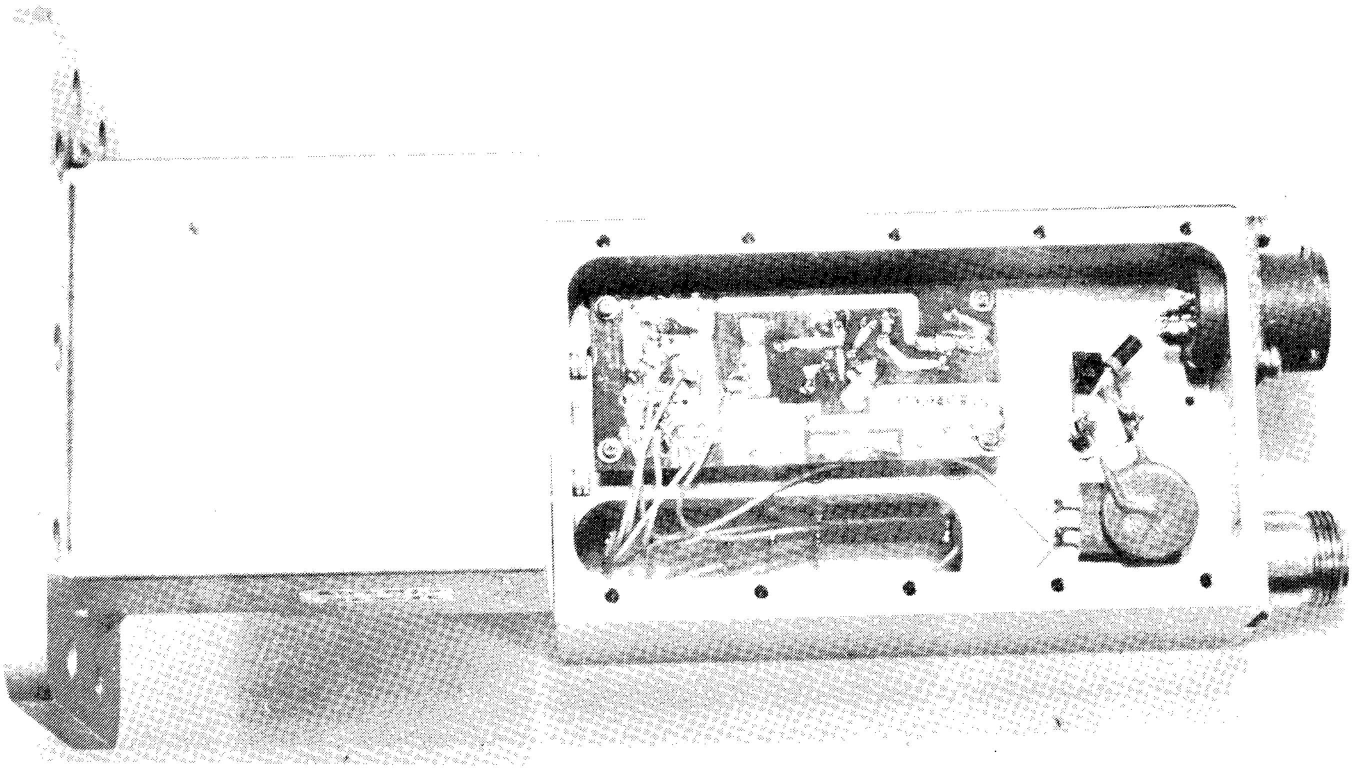
Moisture, anything wet, is your number one "maintenance enemy" at C band. The tiniest amount of moisture, whether it leaks inside of something or condenses from within, forming on any surface of metal (or wire) carrying C band (4 GHz) signals will promptly destroy the signal carrying ability of that metal surface or contact. We'll have more to say about connectors and weatherproofing shortly.

The LNA has a "probe" inside of its mouth. The flange on the LNA mates with the flange on the feed horn; you are in effect butting two "mating pieces of pipe together" so that the C band signals flow from the "rectangular pipe" on the feed into the rectangular pipe of the LNA. The two pieces of "pipe" must mate smoothly, and fit together directly; not skewed or twisted.

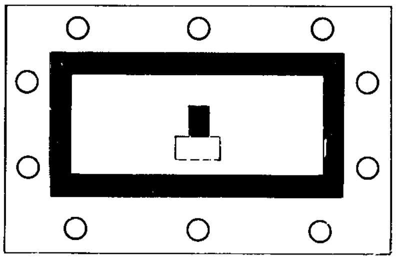
The "probe" is sort of like a miniature "antenna"; it sits inside of the mouth of the LNA and picks up or accepts the C band signals flowing down (up) the pipe. The probe is coupled, directly or indirectly, to the input side of the first GaAsFET transistor amplifier stage of the LNA. It is therefore actually part of the amplifier tuned circuit. This says that nothing (dirt, dust, metal shavings, weather sealing compound, etc.) is allowed to get into this "cavity" or near the probe. Good housekeeping applies here; keep any foreign material out of the LNA "mouth". Also, when there is power applied to the LNA, do not touch or allow anything to touch the "probe". It is in fact a good idea to keep your fingers (and everything else) off of or away from the probe under "static" or non-operating conditions.

Inside of the LNA are several stages of amplification. These stages are "cascaded", or "spread" across the C band frequencies, in such a manner that the "sum" of their individual tuning "curves" equals the full band of interest. This is another way of saying that no **single** stage can typically provide useful gain **and** a low noise figure over the **full** 500 MHz band (3,700 MHz / 3.7 GHz to and including 4,200 MHz / 4.2 GHz). By "staggering" the individual stages (four to five stages total, typically), the designer insures that the desired low noise figure and gain is created evenly over the band.

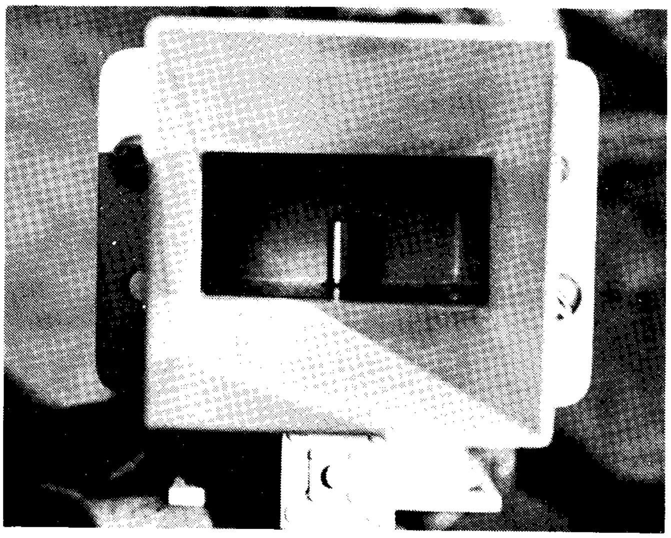
LNAs are sealed; many have stickers on them warning that breaking the "seal" (the result of opening the container) "voids the warranty". Looking inside of an LNA is instructive but (trust us) there is absolutely **nothing** inside of an LNA which you can tweek upon, turn or twist or adjust, **to improve performance**. All of the circuits are tuned by tedious and critical "cutting procedures". Bits of circuit board tuning strips are shacked away at 1/64th inch increments to idealize or



INSIDE AN LNA - bulk gain stages of an SCI low noise amplifier. GaAs-FET stages are in opposite container.



LNA "PROBE" COUPLES ENERGY FROM FEED ANTENNA INTO INPUT OF FIRST AMPLIFIER STAGE.



LNA PROBE shows clearly in mouth of unit; standard "horn antenna" is mounted to front flange of LNA and view is through horn.

optimize the performance of the particular LNA. This is done with (typically) $20,000 and up test stations and by people who have spent years learning their trade. It is not a CB radio with tuning slugs to twist upon!

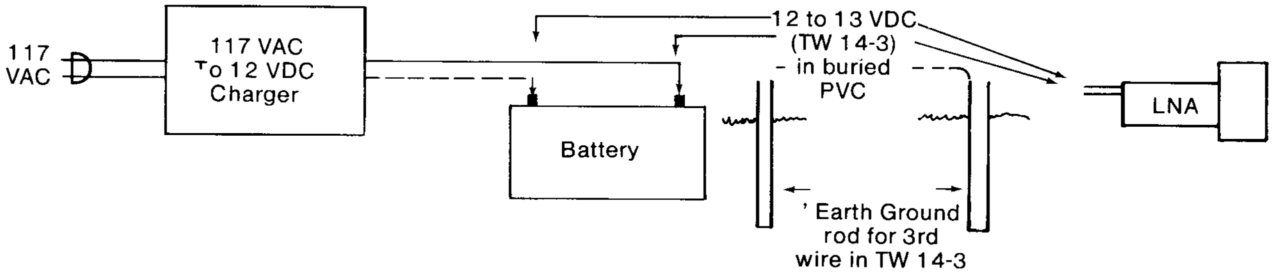
The best advice for LNA repair or tuning is "don't do it...don't even think about doing it". The odds that you can open one, and either fix it or improve it, are at least in the million to one region. And voiding the warranty will or can be very expensive to you.

LNA powering is a subject that scares many people. When LNAs cost upwards of $2,000 each (as recently as 1979), there was a legitimate concern that since LNAs were said to be prone to lightning or power source induced failures, you should do everything you can to protect them. Most LNAs in use today are powered by a DC voltage; typically between 12 and 25 volts. Some LNAs function well with the minimum voltage (12 volts) supplied; others must see at least 18 volts or so to function. DEXCEL and SCI LNAs, for example, function properly with a standard 12 VDC source.

The safest method of powering an LNA is to use a **pure DC voltage** from a pure DC source. A battery is the most pure DC source known to man. One of the systems employed by those who worry about premature LNA failure is to use one or more rechargeable batteries to power the LNA.

Current LNA units are not nearly as prone to failure, created by powering source irregularities, as LNAs in production only a few years back. LNA manufacturers quickly tired of repairing field busted units and set out to discover what they could do, inside of the LNA container, to improve field reliability. LNA failures occur from one of three causes:

1) **A power "surge"** (or transient) comes along the powering line, momentarily raising the voltage to the LNA. Some of the amplifier transistors used in LNAs are very vulnerable to sudden voltage increase and they simply 'snap' like fuses 'blow'.
2) **Lightning strikes**, in the general area, induce electrical voltages of a very high value into the LNA powering line. The result is similar to a sudden increase in the voltage from the regular power supply; transistors "snap".
3) **A component part in the LNA simply fails**, even under


117 VAC
117 VAC To 12 VDC Charger
Battery
12 to 13 VDC
(TW 14-3)
- in buried PVC
LNA
' Earth Ground rod for 3rd wire in TW 14-3

BY OPERATING LNA FROM AUTO BATTERY DC SOURCE, BURYING CABLE TO LNA AND USING 3RD WIRE IN BURIED CABLE AS GROUND WIRE TO EARTH DRIVEN GROUND ROD, PROTECTION TO LNA IS OPTIMIZED.

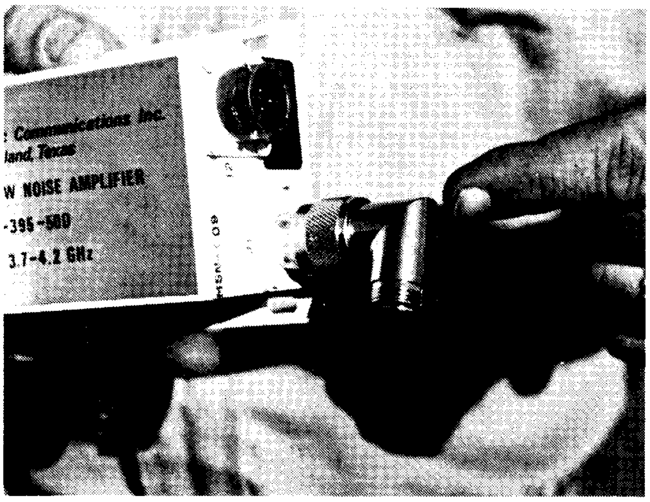
normal operating voltage, i.e. it was less than perfect to begin with, should have been culled out in "device test" but got by the testing station un-noticed.

To protect against powering surges/transients from the LNA power supply you should be using a pure DC supply. If your LNA will operate from 12 to 13 volts, a small automobile battery fed DC voltage from a low cost "trickle charger" will do the job. The commercial 115 VAC source supplies voltage and current to the trickle charger, which in turn supplies 12 volts DC to the battery. The battery, in turn, supplies 12 to 13 volts to the LNA. The battery acts like a giant capacitor or "sump" and it catches and smooths out any sudden surges that come along the line. The typical LNA draws under 200 mA (0.2 amps) so the current drain is relatively low, at 12 to 13 volts.

Alternately, use a separate power supply for the LNA; one that converts 115 VAC to 12 volts DC. The DC should be well filtered (i.e. low "ripple" content, under 1%). The last, and poorest choice, is to use the LNA powering jack out of the TVRO receiver.

A **direct** lightning strike is a disaster and no amount of protection will save the LNA. However, since the TVRO antenna typically presents a low profile to the ground, it is not usually going to attract lightning. Rather, lightning will strike a higher object in the air and voltages from thestrike nearby will be "induced" into the LNA powering line. The best protection for this problem is to place some PVC pipe into the ground and run your LNA powering cable **plus** your TVRO coaxial cable (and your LNA rotor cable if used) **inside of** the PVC. Suspending these lines overhead, or laying them on the ground, provides no protection; place them underground gets them out of most of the induced fields from lightning.

If you will use a 14-3 type underground cable, you can run your positive supply line on one wire (such as white), your negative supply wire on another wire (such as black) and then use the third wire as a ground). Drive a six to eight foot ground rod at the dish, and at the entrance to the building, and strap the third wire to the ground rod using special clamps manufactured for this purpose. In this way you have a good low resistance "ground" at both ends of the LNA supply cable. You also have a way to directly connect the metal support base super structure of your dish to an earth driven ground. Take a piece of RG-214 or RG-8 coaxial cable and remove the outer braid material in sufficient length to connect a clean metal point on the dish support structure to the driven ground rod. Make sure the paint is off the dish support structure, at the point of contact, to obtain a good low resistance ground fo the dish structure.



REAR OF LNA has type N output connector (right angle fitting shown to allow tight fit) and power jack.

If a component part fails, well, that is clearly beyond your ability to repair in the field. However some indication of what may be wrong will be helpful to you since some apparent LNA failures are not the LNA at all.

TYPICAL LNA DEGRADATIONS

The LNA is supposed to have "flat" gain across the full C band, and, it is supposed to have a "flat" noise figure (within specifications) across the band. Sometimes an LNA gets into the field which does not have these desirable characteristics. Here is what happens and how to spot it.

1)The system works good on the low end of the band (such as transponders 1-12 or so) but the pictures get noisy at the higher end.

The situation could be reversed (low end poor, high end good) but the probable cause is the same. One or two stages of the LNA have failed or are failing and the gain and noise figure they "contribute" to the full band is degraded. Any "**partial band degradaton**" (i.e. less than the full 24 channels) indicates a probable failure **in one** of the first three stages of the LNA; one of the GaAs-FET stages is degraded.

2)The LNA is working but after triple checking everything else, the pictures are still noisy.

This could be an antenna or feed problem, but let's assume it is the LNA. The first two or three stages in the LNA provide selective gain over a portion of the band, as noted. And the sum of their individual gains is the full band. However, the **last** stages in the LNA provide "bulk gain" over the **full** band. If one or more of these stages fail or degrades, you get low LNA total output (i.e. gain).

3)The LNA suddenly stops working, or it works at far reduced picture quality.

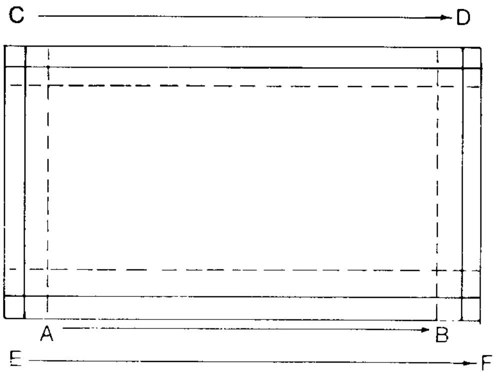
Most LNAs operate their **internal** gain stages at voltages in the 8 to 12 volt region. They accept the specified input voltage (say 15 volts as with the DEXCEL units) and then they "step down" the input voltage to the required 8 to 12 volts wiht a voltage regulator device. Sometimes the voltage regulator will fail, and it acts like a block to the input voltage. A **temporary** fix for this one is to replace the normal voltage source for the LNA with a variable voltage source (such as a lab/bench adjustable power supply). Start down in the six volt region, and very-very carefully increase the voltage up to the normal LNA supply voltage. Around the actual internal operating voltage of the LNA stages (call it 9.6 volts for example), the picture will suddenly "snap back in". In effect, you are riding through the failed voltage regulator by matching the input to it with the normal rated output of the device. This is only a temporary fix, but it can hold you until you can get a replacement LNA in hand. Your substitute (lab/bench) power supply will have to be very stable in output voltage level, however, for this to work; the "window" at which you can sneak by the failed voltage regulator may only be 0.1 or less volts wide!

NON-LNA TYPE LNA FAILURES

Many installations suffer from "rolled off" gain or response at one end of the band or the other. More often the low end will be "down" than the high end although it can go either way.

The mechanical configurations in the feed, the "waveguide pipe" connecting the feed to the input flange on the LNA and so on are of precise physical dimensions. They are "so high" by "so wide", **on purpose**.

If the dimensions get smaller than they should be, the slightly longer wavelengths found in the lower channels are in effect blocked off or "cut off" from flowing through the system. Many of the early feeds in the business were slightly too small in dimensions, and people found the lower transponders were not as strong as the higher transponders. While it is possible for this to happen over several of the lower channels, typically this happens only over two or three transponders. The solution is to look carefully at the feed and try another one that shows slightly larger dimensions.



IF FEED, LNA, FLANGE OPENINGS ARE TOO SMALL (A → B) LOWER CHANNELS ARE DEGRADED. IF OPENING IS TOO LARGE (E → F), HIGHER CHANNELS ARE DEGRADED. OPTIMUM SIZE IS 2-5/16THS BY 1-5/32NDS, APPROXIMATELY.

If the dimensions get too large, the opposite end is effected; the high end of the band. Again, if the top few channels look bad, it could be the LNA but it could also be something in the feed system restricting the flow of the shorter wavelengths.

Moisture is a constant source of degradation. Most systems install a relatively short length of flexible or semi-flexible cable (such as RG-214) between the output of the LNA and the "hardline" which carries the signal to the receiver. This is done for two reasons:

1)It is sometimes difficult to fit non-bendable (or non-flexible) "hardline" to the LNA output connector; it is simply not located where you can get hardline to it. A short section (typically two feet or less) of 214 type cable will get you the flexibility you need.

2)If you are rotating your antenna feed, to select between vertical and horizontal polarization, you are in effect twisting or turning the LNA. This causes more stress on hardline than hardline (and connectors) can stand. So once again we install a short piece of flexible cable.

The flexible cable has a type N connector at the LNA, and a second type N connector at the opposite end. The hardline has a type N connector also. If both of the to-mate ends use a male type connector then a "splice connector" (such as a Amphenol UG-29 B/U) will connect the two together. It is also possible to place a female N connector on one or the other cables (flexible or hardline) so that the two mating ends will plug **directly** together. In either event you are "splicing C band energy" out there in the open air and that is asking for problems.

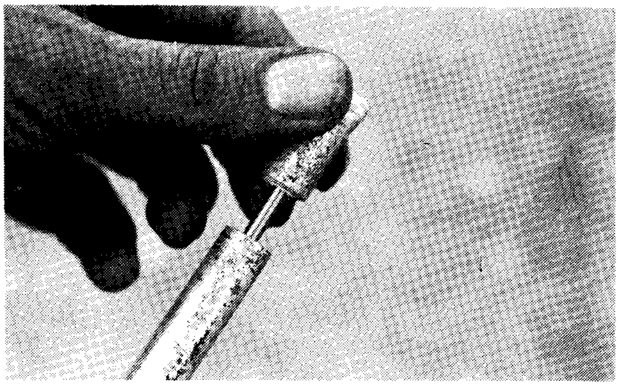
Any connectors carrying C band signal energy must:

1)Be very carefully prepared and installed on the cable. Tyep N connectors are **not** easy to install, properly. If you have not done this before, either have it done for you or spend a couple of hours following the instructions packed with most connectors, to do it properly. The most common problems in improper N type connector installations are:

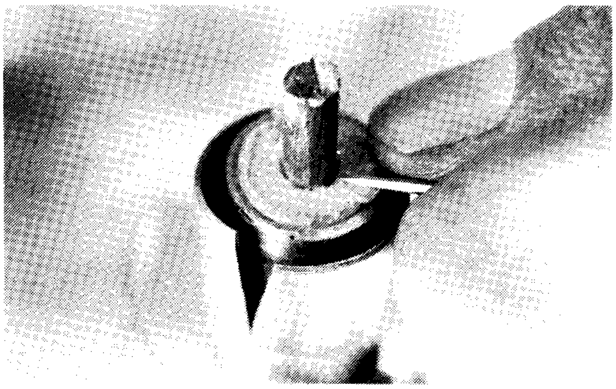
A)The center pin, which installs on the center conductor of the coaxial cable, sits too far out, or, too far "in", within the connector shell. It should protrude at its tip out to the ring that surrounds it; no more, no less.

B)The shield, which must be soldered (for flexible cables) to a circular insert that is physically wedged into the body of the connector, does not make good electrical contact with the circular insert. The braid shield must be soldered fully around the circular insert and the solder must be very thinly applied or the solder build up will keep the circular insert from fitting properly into the seat in the connector body proper.

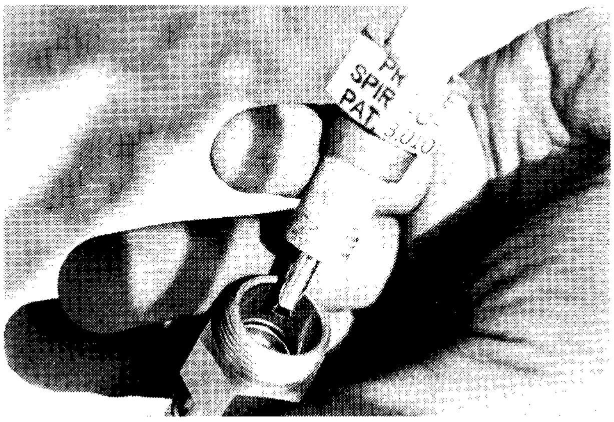
C)When screwing the connector together, the circular insert to which the shield is soldered is often not properly seated down into its 'bed', inside of the connector. You will notice that you cannot properly tighten



USE TUBING cutter to carefully cut through outer cable jacket/shell, and pull off section per connector instructions.

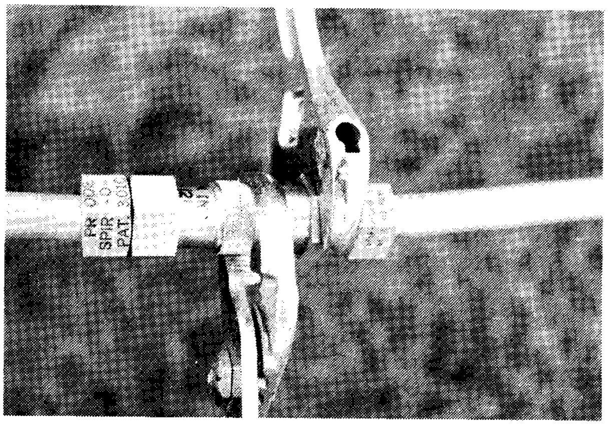


CLEAN copper center conductor carefully of residue and insure no metallic parts have fallen onto foam insulation.

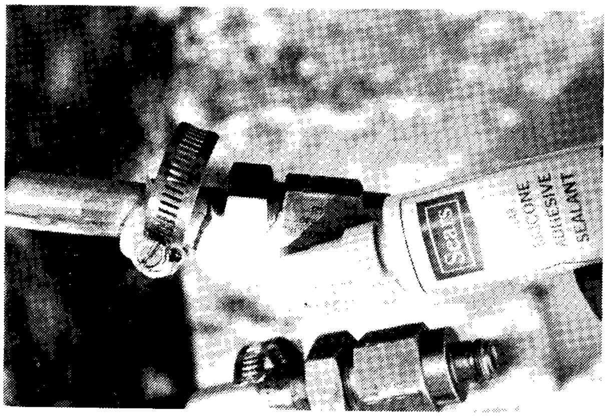


INSTALL connector parts carefully following instructions packed with connectors; nothing should have to be forced with more than "hand pressure".

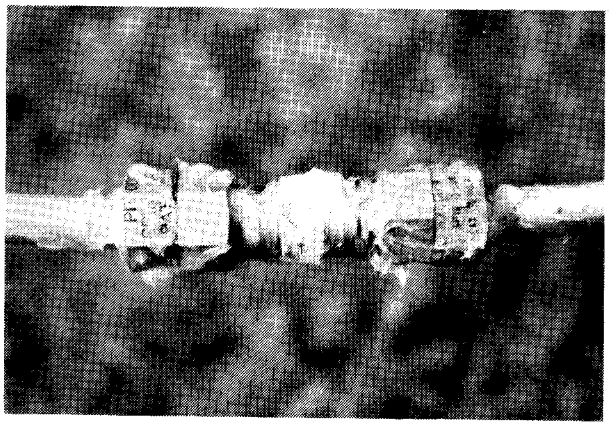
the top portion of the connector, with a wrench, down to where it is flush and firmly seated to the body of the connector.



TIGHTEN (carefully) connector shells together; nothing should "move" with hand pressure when completed.



APPLY BEADS of sealing compound around all areas which could allow moisture to "leak" into connector.



LIBERAL use of sealing compound will help prevent moisture ingress or connector "breathing".

Cable is supplied in many forms. The cable usually has a PVC type jacket (black, hard plastic looking material) under which you will find either smooth aluminum, or corrugated copper. Under the aluminum/copper you will find either a white "foam" (plastic) dielectric, or, spiral of hard white plastic with air gaps between the spiral.

The outer jacket is weatherproofing. It can be obtained either "dry" or "flooded". Flooded cable means there is a self sealing compound under the jacket, between the under side of the jacket and the hard stuff below. If the jacket gets nicked (cut by a sharp rock, or whatever), the flooding compound fills in the puncture in the jacket insuring that moisture does not slide in under the jacket and "creep" through the cable. The solid aluminum, or the corrugated copper, is the "shield". It is the same as the woven braid on flexible cables. It is actually part of the coaxial signal path, plus, it acts as a barrier to the ingress of interference. It also supplies the physical strength to the cable.

The inner foam is an insulation material. The spiral wound plastics does the same thing, except it substitutes air (the best insulator) for as much of the inside as is feasible without sacrificing the strength of the cable. The center conductor, typically solid copper (although some is copper covered aluminum), is the primary signal carrier.

Solderless connectors are like **plumbing** fixtures. They have a main body which includes a center conductor insert (pin) plus a screw on top which makes a physical and electrical connection to the shield. You prepare this cable using a tool called a "tubing cutter"; a small hand held device that is sold at hardware stores and is used by plumbers and electricians (to cut metal conduit). The instructions for how far back to cut, where to insert which piece, and the sequence to follow in installing the connector vary from connector to connector. However these generalized warnings:

1) After preparing the cut with the tubing cutter, cut only through the aluminum/copper outer shield. Then take off the tubing cutter and complete the cut through the foam/spiral inner insulation with a sharp knife. Be very careful **not** to nick or cut the copper inner center conductor in the process.
2) Gently pull the outer shield (and foam) off of the cable end, and inspect the center conductor. If you have nicked it, start over.
3) Take a pen knife and gently **scrape the full surface** of the center conductor so it is a bright, shiny copper. Foam insulation has a stickiness, that will adhere to the center conductor copper, and this stickiness is actually a thin layer of foam insulation. **It has to be removed** or you will lose signal here. Even when the copper **looks** clean, there will be an oxide coating on the copper which should be gently scraped off. You want a bright, shiny copper finish, clean of all residue, to insert into the center conductor pin of the coaxial connector.
4) Carefully inspect the **end** of the cable, if it is solid foam filled, to see if there are any particles of copper or aluminum sticking to or stuck into the foam. There should be no metal particles here at all; nothing but pure, white foam. Any particles here can cause an "impedance bump" or even an "short" to the C band signal energy.

Follow the instructions as to cutting the center conductor to the proper length, so that it seats down fully into the center pin. Make sure the center conductor is not so long as to hold the foam portion (flat end) of the cable "up" from sitting down, firmly, on the inside of the connector.

The screw on shield portion has an expandable ferrule in it; the ferrule will bite into the shield of the cable as you tighten up the top portion. Firmly hold the bottom of the connector with a wrench and turn the top portion with the second wrench. Make very sure that as you do this the cable is not "backing out" of the connector; it must stay seated, firmly, down inside of the connector.

Every connector must be protected from moisture ingress. There are numerous methods of doing this. Some people like to use a heat shrinkable plastic tubing product which goes over the joint, and then with a modest amount of heat from a small hand torch "shrivels" up to produce a tight weather shield. Our technique is as follows:

1)Tape a fresh roll of outdoor rated "tap tape" (i.e. plastic, rated for outdoor use) and start on the 'top' end of the connection/splice. The top end is the end that is highest above ground. Start two inches above the connector, **on the cable body proper**, and tightly (pull and stretch the tape) wrap the cable down over the connector and go to a point two inches beyond the "bottom" of the connector. Now, without breaking the tape, repeat the process going back "up" the connector to the point where you began.

2)At the top end make several tightly pulled wraps around the cable and **cut** (don't pull or stretch) the tape. Make sure the end is firmly seated down on the cable.

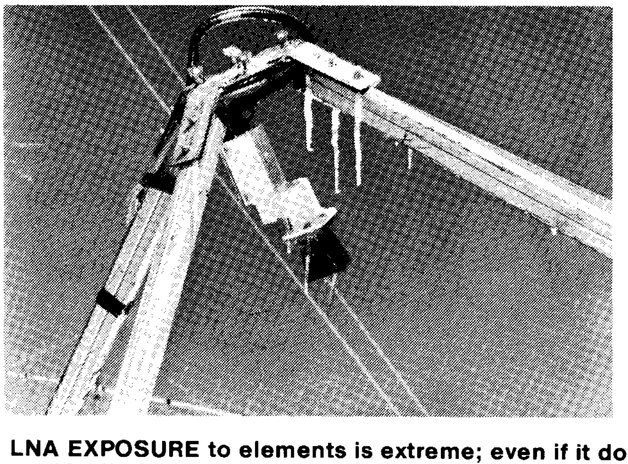
3)Now take some common hardware store bathtub caulking compound and spread it liberally over the connector/ splice. Smooth it out, working it in over the taped area, going above the top end and below the bottom end of the tape by ½ inch or so.

The tape will insure that moisture does not get into the connector; the caulking compound will insure the moisture does not get into the tape. Between the two you will be able to come back ten years later, even in a harsh environment, and find the connection inside dry as a bone and free of corrosion.

A very slight amount of moisture, leaking into **or** condensing inside of a connector or splice will turn your pictures to snow. Moisture will attenuate signals, and once inside of the connection, it will create a high humidity level which will quickly corrode the inner (usually silver plated) parts. If you see your signals gradually failing, especially if you can see it happening after a heavy rain, go look at your connections.

The N type connector coming out of the LNA is usually difficult to properly tape since there are supports and power plugs and other items packed in a close space. Here we simply use the calking compound, even if the LNA is inside of a feed enclosure. Remember, moisture condenses inside of warm objects that turn cooler. Water does not have to **leak** or pour into a connector to cause problems; it can 'seep' in when the connector "breathes".

Likewise there is a power connector to be considered. Most connectors for LNAs have a very well **designed** weatherproof housing. However, most people defeat this protection by not properly insuring that the cable end going into the connector is firmly sealed. The LNA sits cocked at an angle, **pointing down** slightly. If the LNA does not have a covering or enclosure (many antennas now include a cylinder housing that covers over the LNA, feed and rotor), rain can leak down inside of this connector and short out the DC supply. Protect it if necessary; you don't want water collecting in the LNA power plug!


LNA EXPOSURE to elements is extreme; even if it does not "ice" where you live, heavy rains and fog can also do damage. Be prepared - protect the LNA and all fittings!

Flexible cable can be handled in a fairly sloppy manner provided:

1)Do not place it where any sharp metal can puncture or pierce its outer PVC jacket. If the jacket gets pierced, water will leak into the shield and 'creep' along the foam in both directions. This will corrode the copper braid (or silver plated copper) and turn it green. **Long before** it gets an ugly green, you will have a high cable impedance at that point and strange things will start to happen to your picture. Don't allow the PVC jacket to get creased or nicked or slit.

2)Flexible cable can bend, but not "back on itself". Avoid anything sharper than a 30 degree bend in an area equal to ten times the cable diameter.

"Hardline" is more difficult to work with, but lower in loss. We'll talk about loss shortly. Hardline cannot bend except in very gradual sweeps. If you bend it too tightly you will instantly notice a "bubble" or "ridge" **under** the PVC jacket. That will be a good time to say "damn", and start over. **Any ridge you can see or feel** is going to do nasty things to the C band signals.

Likewise, the PVC jacket cannot be nicked or cut unless you are using a "flooded" type of line (typically available only in the solid aluminum sheath format).

COAXIAL CABLE LOSS

First let's decide that there are many types of hardline around. Hardline is not a brand name; it is a generic term. It means any cable that has a solid (or solid-like corrugated) outer shield).

The hardline you want is 50 ohm. There is an abundance of 75 ohm hardline about these days; it is used widely in the CATV/MATV industries. There is nothing wrong with 75 ohm hardine, except that it requires different connectors than the 50 ohm stuff. And 75 ohm connectors have a different size of center pin which will not properly seat into (for example) the N type female fitting on the back of your LNA, or the similar fitting on the back of your receiver. You cannot **force** 50 ohm connectors onto 75 ohm hardline and expect decent 4 GHz performance. So if you find some "cheap" 75 ohm hardline, pass it up. It can cost you a whole bunch of signal dBs since there is no practical way to make the connections on either end to 50 ohm equipment. Plus - if you use it, you will have a rather serious impedance mis-match between the 50 ohm LNA and the 50 ohm receiver, and, the 75 ohm hardline. A mismatch is another way of saying that you lose signal; something to be avoided of course.

Now 50 ohm hardline, that has a solid aluminum jacket, and a solid-appearing foam inner insulator (dielectric) is **commonly used** for C band service. This may be unfortunate because:

1)There is a plentiful supply of ⅜", ½", and ¾" aluminum jacketed hardline, 50 ohm, on the market. And...

2)Very little of this cable has been rated to the relatively high frequency of C band.

Here is what that is all about. All cable is designed for specific, specified, uses. Some cable has extra care and precision built into its design so it can be used efficiently at microwave frequencies. Other cable is intended to be used only to 500 or 1,000 MHz or so. The cable **manufacturer** will honestly tell you the upper frequency limit for his cables. A distributor or dealer, unaware of the limits, may not be able to tell you this. The bottom line is quite simple; just because it is ½" (or whatever) hardline does **not** mean it has low loss at C band (4 GHz). In fact, the odds are it will have only slightly less loss than the flexible RG-214 stuff.

3)Additionally, connectors for hardline are also rated in maximum useful frequency. They may be rated to C band; or they may not be.

Again, the bottom line is that 'hardline connectors' are not automatically "good" at C band.

Any cable you plan to use, whether for a single installation or for multiple installations of a commercial nature, should be suitable for the purposes. The same applies to connectors. Ask or demand to see manufacturer's specifications for 4 GHz oepration before you accept **any** cable or connectors; or accept the consequences.

What might the consequences be? Well, mostly they will be abnormally high signal loss. All cable has loss. No cable is a perfect transmission medium, or conductor. All cables lose more signal (per foot, 100 feet, etc.) at higher frequencies than at (relatively speaking) lower frequencies. Our C band is a high frequency.

Cables designed to be efficient conductors at C band, such as the Andrews Heliax ® line of cables, have relatively low amounts of signal "loss" per 100 feet; 4 to 5 dB per 100 feet, is typical. By comparison, cables such as RG-8/U (a flexible cable commonly used at VHF frequencies) are not even **rated** at 4 GHz, but in practice can exhibit losses as high as 30 dB per 100 feet at C band.

Virtually any flexible cable (including RG-214) will have relatively high losses at C band; at least in the 14 to 15 dB per 100 feet region. Many of the ½ inch hardlines **not** rated to 4 GHz will **also have** between 12 and 15 dB of loss per 100 feet at C band. An improper (i.e. not 4 GHz rated) connector can add another couple of dB of loss; at each end.

Now loss sounds like something to be avoided. It is not the end of the world to have loss, as long as the amount of loss is "controlled". What we have here is a question:

A)How much loss can the installation in question tolerate, before loss starts to effect signal quality?

The TVRO system is a mixture of gains and losses. Someplace between the reflector surface on the dish, and the video/audio signal coming out of the TVRO receiver, we must attain certain specified amounts of gain. And the gain must be fairly evenly balanced at 4 GHz, and, at our receiver IF frequency(ies).

A dish, for example, has gain. A ten foot dish exhibiting 40 dB of gain is considered to be a very good ten foot dish. The next gain item is the LNA. A commercial LNA will typically have 50 (+) dB of gain. The LNA has to do two things:

1)It has to be high enough to counteract the loss of the cable connecting the LNA to the receiver, and,

2)It has to be high enough after the cable losses to override the "noise figure" of the receiver proper.

This then seems like a fairly simple thing to calculate. If we have 50 dB of LNA gain, how much of that LNA gain do we need to override the receiver noise figure (by "overriding" the receiver noise figure with LNA gain plus the lower noise figure of the LNA, we establish the system noise figure with the LNA). Unfortunately, there is not a simple, single answer to the last portion of the question.

Some receivers require twice as much LNA gain, ahead of them (as a minimum) as they have (dB of) noise figure. A very good receiver has at least an 11 dB noise figure and many have 15 dB noise figures. Others require slightly more than twice as much gain.

So if we have an 11 dB receiver noise figure, to make the LNA the "dominant system noise figure", we will need at least twice 11 dB, or 22 dB, of LNA gain reaching the receiver. If we start off with 50 dB of gain, and we need a minimum of 22 when we get to the receiver, then we can afford to 'give up" 28 dB of LNA gain in our cable.

And, if our receiver has a 15 dB noise figure, and it needs 2.2 times the noise figure to realize the system noise figure created by the **low** noise amplifier, then we need 2.2 times 15 or 33 dB of LNA gain to reach the LNA. And that says we can afford to lose 50 - 33 or 17 dB in our cable **and** connectors.

Now each of these examples allows for worst case performance; that is, the **minimum** amount of LNA signal voltage (expressed as dBs of signal gain within our LNA) to arrive at the receiver, to make the receiver work. Obviously, anything less than this arriving at the receiver (i.e. additional cable losses or less LNA gain to begin with), will degrade performance. Perhaps it is also wise to look at the other end; too much signal. Or, at least, more signal than is required for proper (marginal) receiver performance.

Some receivers (the earlier ICM units are an example of this) cannot handle high input signal levels; they simply 'overload' from the extra signal. Other signals 'tuck' the extra signal away as a 'cushion' against signal fading, or system losses that build up with time. With so many new receivers on the market, it is impossible to cite each receiver's reaction to too little, or, too much LNA gain in front of them. Too little gain causes:

1)**Noisy pictures** (unfortunately you get the same result with too little antenna gain or a mis-pointed antenna)

2)**Pictures that exhibit ragged**, 'noisy' edges; you usually noitice this first on the weaker transponders.

On the other hand, too much signal gain (for the particular receiver to handle) causes:

3)**Pictures that turn 'saturated'**, that is whites become "super white", colors bleed, and the picture is filled with jitters and unstable. The audio may also buzz.

The quickest way, perhaps, to determine whether you have too much gain is to detune something. That is, get less signal into the system so that the amount of signal voltage arriving at the receiver is reduced. You can:

1)Slightly move the antenna so the signal level to the LNA is reduced, or,

2)Add in 50 feet or so of RG-8/U cable (known to be high loss cable!) which acts as a 'pad', attenuating the signal voltage from the LNA. If the first 50 feet makes the pictures better but they are still degraded, add some more.

To determine whether you have too little signal (remember - too much cable of the wrong type, a bad coaxial cable connector, moisture can do this), you'll have to add some additional gain to the system to see what happens. There are two ways to do this:

1)International Crystal Manufacturing Company (ICM) has a unit called a 'purifier', which is a combination of a bandpass filter and a 'post' amplifier. "Post" means you would never use it as an LNA, but you can use it **after** an LNA. The gain of the amplifier is sufficient that if you are suffering from too much cable/connector loss ahead of the receiver, adding the Purifier will **improve** things. If you add a purifier and nothing improves, you now know your problem is either with the LNA proper or the antenna. The Purifier installs at the receiver end of the cable, goes "in line", and operates from a 12 volt source (DC).

2)You can 'gang' LNAs although there are warnings here. If you have one LNA at the antenna (in the normal fashion), and a long or lossy cable run, you can place a second LNA at the receiver end of the cable. You do this by adding a new part (Type N transition block for C band, from Waveline, Inc., Fairfield, N.J.) to the second LNA. The transition block bolts to the LNA flange (flange to flange) as shown here and it has a small probe, inside, which is aligned with the probe in the LNA. The block has a type N fitting on top so with it you have a way to connect a standard piece of coaxial cable, carrying C band signals, to the input of an LNA. This turns the LNA into a 'post amplifier' or "line amplifier". You will have to provide operating power to the second LNA of course.

Now the warning here is that, by adding a second LNA, you have just increased by 50 dB the amount of 4 GHz amplification. That is a bunch **to add** to the system although there are situations where you can use it. You can easily go from too littlle signal to too much signal, to the receiver, with this. A variation would use a lower gain LNA (30 dB gain LNAs are available from some suppliers; and Amplica and Avantek offer 4 GHz 'post amplifiers' designed especially for this purpose). If you try out this approach and find you are now overloading your receiver, stick in a bunch of higher loss cable (RG-8/U for example) **after** the second LNA and on the way to the receiver.

LINE SPLITTERS

A TVRO antenna system can be used to connect up more than a single receiver, with certain cautions. As long as the received signal **voltage** is strong enough to stand being "divided" into equal parts (2, 4 or 8) you can connect a "line splitter" to the inside end of the coaxial cable and then connect up additional receivers. If your received signal voltage is marginal for a single receiver (because of line/connector losses), the addition of a line splitter will usually take you below the "threshold" point. Therefore some planning, using post amplifiers if required, is in order.

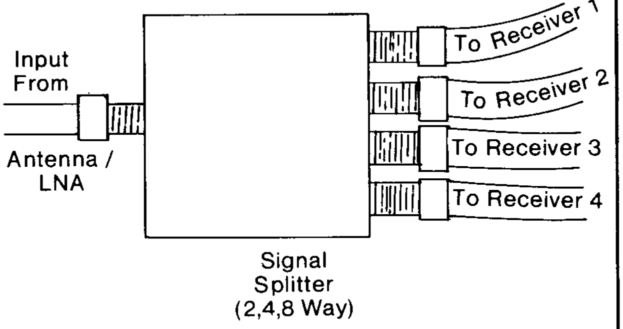
Line splitters are available from many sources. One, Merrimac Industries of West Caldwell, N.J., publishes an excellent set of application notes on using line splitters for TVRO service.

the "sufficient voltage" problem aside, there is one more warning about using two or more receivers from the same antenna. And that is the "single conversion receiver LO problem". Generally speaking, there are two different design approaches to TVRO receivers around. One technique takes the incoming 4 GHz signals and frequency converts the incoming signal first to something called a "high IF" where the signals are further amplified and filtered. The Sat-Tec and ICM receivers, for example, typify this approach. Then the high IF signals, usually in the 1000 to 1300 MHz region, are converted a second time; this time down to the 70 MHz region where they are again amplified and filtered. We'll look at receivers shortly.

The second design approach, typified by AVCOM, KLM, and many others, does only a single frequency conversion. They drop from the 4 GHz incoming frequency range all the way down to 70 MHz in one step. When this approach is followed, the receiver produces an "in-band" signal in the conversion process. The in-band signal is present in the full receiver system and it is capable of interfering with normal reception by additional receivers connected to the **same** antenna.

This is not an insurmountable problem for the system designer, but the solution can be expensive. It involves "isolating" each receiver from the system, using a device called (appropriately) an "isolator". The isolator installs at the **input** of the receiver, between the receiver and the output coming from the line splitter. Each receiver connected to the system, employing the single conversion reception technique must be "isolated" from the others on the antenna; even if the others are dual conversion.

For this reason most systems that plan to employ two or more receivers, in operation simultaneously, will select dual or double conversion receivers since they do not require isolators to function in a "shared antenna" situation.

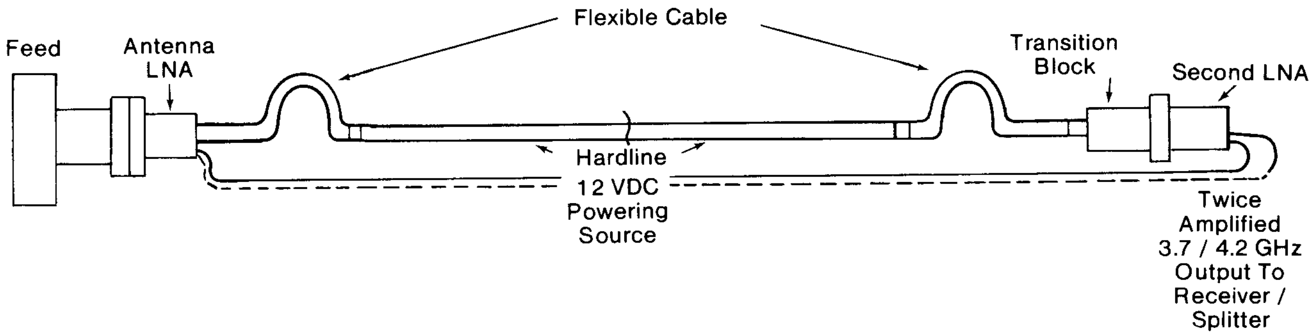


TWO OR MORE RECEIVERS CAN BE DRIVEN BY SINGLE LNA / ANTENNA, WITH SIGNAL SPLITTER DEVICE, PROVIDED SUFFICIENT SIGNAL "VOLTAGE" IS PRESENT TO ALLOW "SPLITTING".

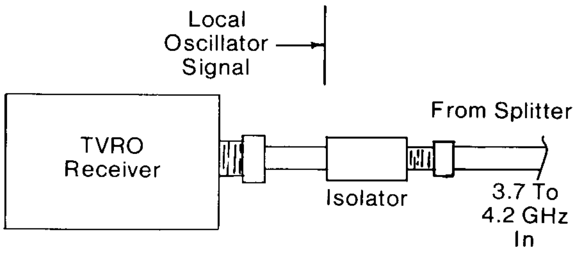
VARIATIONS

There are a number of variations to the basic systems outlined here. Not all LNAs are powered via a separate powering line, for example, and there are occasions with some commercial type installations where two or more receivers will be connected to both vertical and horizontally polarized signal sources simultaneously.

1)*Duplex Powering* - Long ago it was found desirable in terrestrial reception services to combine or "duplex" on



SECOND LNA CAN BE USED TO RE-AMPLIFY TVRO SIGNALS WHEN FEEDLINE LOSSES ARE EXCESSIVE AND/OR LARGE NUMBER OF SIGNALS WILL BE RECEIVED SIMULTANEOUSLY ON MULTIPLE RECEIVERS THROUGH SIGNAL SPLITTER(S).



ISOLATOR, INSTALLED AT RECEIVER INPUT, REDUCES "BACK-FLOW" OF RECEIVER LOCAL OSCILLATOR SIGNAL TO SIGNAL SPLITTER AND THEN INTO OTHER RECEIVERS.

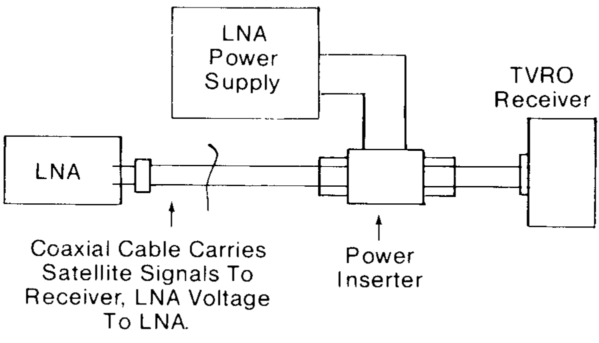
the coaxial cable connecting the signal amplifier (LNA) to the receiver both the downward bound signals, and, the upward bound amplifier powering source.

Duplex powering is a relatively new technique to the TVRO field, but it is based upon sound engineering and should not be feared. Direct current voltages, such as the typically 12 to 26 volts or so used to power LNAs, can be fed in coaxial cable just like any other cable. It can flow "in one direction" (such as from the receiver end to the LNA end) without causing any interference wiht the microwave radio frequency signals traveling "down" the line from the antenna to the receiver.

"Inserting" the DC voltage onto the line requires a device called a "power inserter", or duplexer. This unit mounts near the receiver and it accepts power from the DC source. With special bypass capacitors it isolates the DC power source from the 4 GHz region C band signals. At the LNA, the single (coaxial) input cable allows C band signals "out" and DC voltage "in".

The primary caveats with duplex powering are as follows:

1)If you have a power inserter installed, and your wish to change out an LNA from one designed for duplex powering to one not so designed, you will then have to feed power to the replacement LNA witha *separate* power line. Do not (*ever*) run power up a coaxial line *to* an LNA that has *not* been designed for duplex powering.



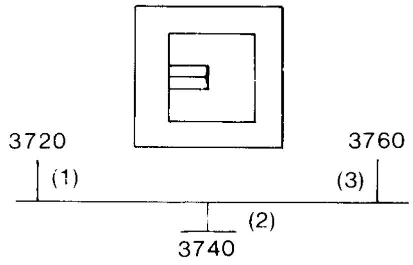
2)The power inserter devices are often confusingly marked as to which end is which. If you swap the ends, the DC voltage will go not to the LNA, but rather to your TVRO receiver. Some receivers will go into a destruct mode if they get DC voltage into their inputs. Very carefully study the instructions with the power inserter, and if they are crystal clear, check with the manufacturer *before* installing it and applying power.

3)When you pull a coaxial cable off of an LNA, and that cable has DC on it, you must be extra careful with the *dangling* end of cable (connector). Type N connectors have a center pin that is easily shorted against a piece of metal at the antenna. Normally this would not make any difference; *but*, with power *in* the coaxial cable, shorting or touching the center pin against a ground will probably blow out your LNA power supply.

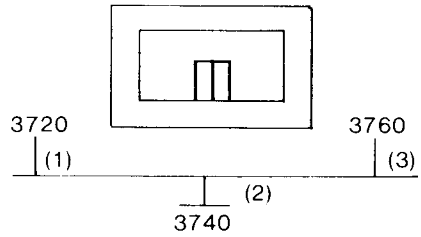
Some people have expressed concern about electrolysis. This is an electro-chemical reaction that occurs when moisture, a DC voltage and similar (or dis-similar) metals get together. Look at the battery terminals on the top of your auto battery. Seek that white, flakey junk? That's the direct result of electrolysis.

Electrolysis, if it formed, on a 4 GHz carrying connector, would kill the signal in very short order. However, if the connector that carries C band plus DC is properly sealed against moisture, chances for electrolysis are slim indeed. Electrolysis requires large amounts of current. The 0.2 amps normally drawn by an LNA is *probably* too low a current to cause electrolysis, provided there is no overt amount of moisture present. Weatherproofing C band connections is always important; when you are also carrying DC voltage in the cable, it becomes doubly so.

2)*Simultaneous Vertical / Horizontal Reception* - All modern satellites of recent vintage utilize a cross polarization scheme wherein the same frequency "band" (3,700 to 4,200 MHz / 3.7 to 4.2 GHz) is used twice. The satellite has duplicate equipment on board which allows it to process one set of signals horizontally polarized, and

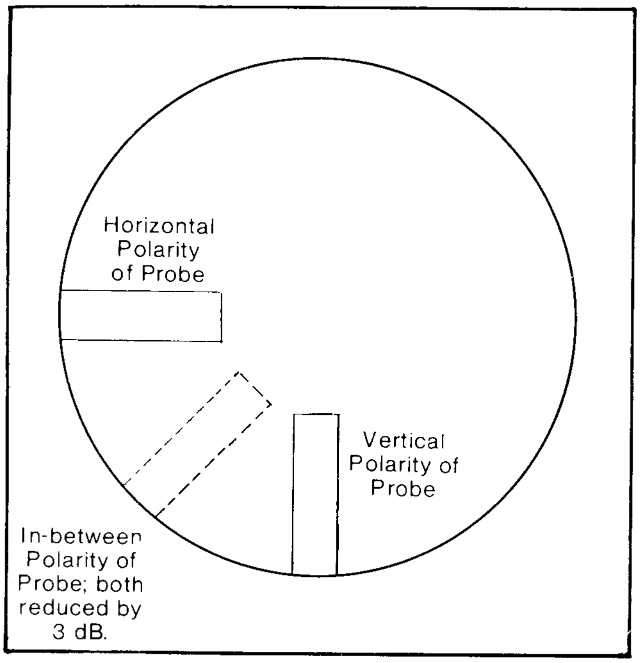


WHEN POLARITY OF LNA PROBE MATCHES, OR CORRESPONDS TO INCOMING HORIZONTAL WAVE (TR 2 ILLUSTRATED), YOU RECEIVE HORIZONTAL SIGNALS.



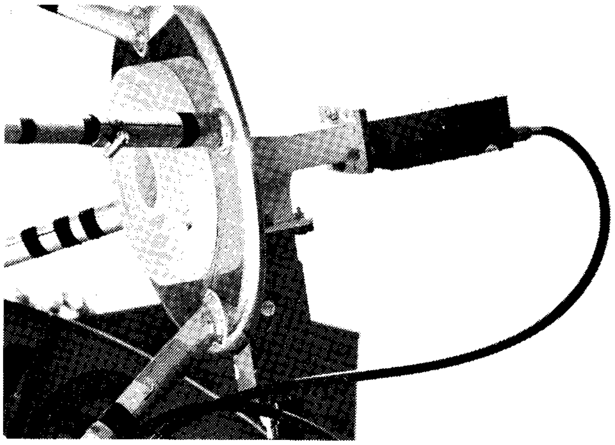
WHEN POLARITY OF LNA PROBE MATCHES INCOMING VERTICAL WAVES (TR 1, 3 ILLUSTRATED), YOU RECEIVE VERTICAL SIGNALS.

another vertically polarized. With a slight "20 MHz offset" the two sets of 12 transponders "share" the same frequency spectrum.


Horizontal Polarity of Probe
Vertical Polarity of Probe
In-between Polarity of Probe; both reduced by 3 dB.

This creates a method wherein you can either turn (as in rotate) your receiving feed antenna, to change from one polarization to the other, or, you can use a special feed and recover *both sets* of transponders at the same time. In many of the more sophisticated private systems, and most commercial systems, it is desirable to recover *both* polarizations at the *same* time. This gives the terminal planner independent access, through two or more receivers, to program sources that are not sharing the same polarization.

The special "cross pole feed" has a device built into it which acts much like a prism does in optical fields; it "beam splits" the two signals coming into the feed horn system and sends all of those transponders that are vertical out of one "port" (or opening) and all of those that are horizontal out of a second port.



DUAL POLE (cross pole feed) has two outputs and a separate LNA connected to each. This allows simultaneous reception from both polarities without rotation of feed.

This type of feed has a pair of ports, then, and to *each* port you attach an LNA. One of the LNAs amplifies the vertical signals while the second amplifies the horizontal signals. At this point you are still at the antenna, at the feed, but you have two separte sets of "polarized" signals. To get them to the receivers you must use a *pair* of downlines; two pieces of coaxial cable. Once inside you treat each downline as if it was a separate antenna, connecting it to a single receiver or to multiple receivers, each of which is fed through a signal divider (splitter).

"Cross-pole" feeds used to be quite expensive. They are now down where they cost from 50 to 75% more than a single pole feed. Thsi is not a bad bargain since the "dual pole feed" also has the mechanical beam splitting or "ortho coupler" system included.

There is nothing complicated nor complex about a dual pole system. Simply think of it as one antenna reflector, connected through a single feed antenna, to a *pair* of separate, but equal signal processing systems. With this approach you can access with out feed antenna rotation all of the vertical, and, all of the horizontal polarized signals through two separate, distinct pieces of feedline.

THINGS TO COME

Because this new STT Manual is being released during the Omaha SPTS '81 Seminar, a few words are in order concerning a *totally new approach* to simultaneous reception from both polarizations.

Most people have noticed, as they rotate their single polarity feed horn wiht a feed rotation scheme, that if you slow down and then stop the feed rotation system motor at just the "right" spot you can actually see *both* the vertical and horizontal signals at the *same* time. Unfortunately, you cannot see them independent of one another; they are "all mixed up".

This fact has challenged engineers in this field for many years. *"Surely"* they thought *"there must be some way to separate these two equal but mixed up signals!"*. Well, it turns out there was a way to do this. And while probably tens of thousands of man hours at some of the most prestigious engineering labs in the world have been devoted to solving this perplexing problem, it remained for a quiet, self taught electronics wizard in the back country of South Dakota to resolve.

Remember that vertical and horizontal polarized signals "share" the same spectrum space. Also remember that these vertical and horizontal transponders are "offset" in frequency from one another by one half of a transponder width (*see diagram here*).

So when you park your antenna feed probe halfway between vertical and horizontal, you are actually receiving equal signals from both polarizations. It turns out that the "equal" signals are *less*, by 3 dB or one half power, than you would receive if you "peaked" the polarization feed probe on *either* vertical *or* horizontal.

The trick is to design a receiver that sees both inter-mixed signals, but which accepts only one of the polarizations at a time. Think of it this way:

1)With the feed parked half way between vertical and horizontal, you have both sets of channels. Now, rather than being 40 MHz apart (as they are center of channel to center of channel, with a single polarization) they are 20 MHz apart from the center of the first channel (vertical TR 1) to the center of the second channel (horizontal TR 2).
2)Both polarizations may now be amplified by a single LNA; and mixed up as they are, fed to a single frequency converter to take them away from their C band frequency range to a new frequency range.
3)The new frequency range, as we shall shortly see in our receiver study section, is called an "IF", for *i*ntermediate *f*requency. The IF is typically low enough in frequency that you *could* design a special television receiver to directly tune this frequency range; if you wished to do so.
4)The special television receiver can then have a very

special detector circuit in it, which tunes not in 40 MHz wide "steps" from channel to channel, but rather in 20 MHz wide "steps" from channel to channel. It "detects" energy which is inside the 20 MHz wide passband of its special tuner/detector and even if some of that energy is coming from a cross-polarized immediately adjacent transponder, it simply rejects the adjacent channel energy because that energy is not "centered" on the channel being tuned in.

At the Omaha SPTS event, the first public display of this exciting new technology is taking place. With this type of approach, one master antenna reflector, coupled to one master LNA and feed and one master down converter stage, can provide the full 24 channels of a fully loaded satellite to one or as many different receivers as wish to be connected to the master antenna. The system is called *"SCDN"* which stands for Satellite Cable Distribution Network. With the SCDN system, a relatively inexpensive section of coaxial cable, carrying the "IF" signal band (all 24 transponders) can be "trunked" about a neighborhood, condominium, apartment complex or what have you. Each individual viewing location "pugs" into the SCDN master cable in precisely the same way that homes now plug into master or community / cable antenna system cable plants. In each home a specially created receiver, designed to tune in the 20 MHz wide format of inter-mixed vertical and horizontal transponders carried together, receives all of the transponders delivered and displays them on the screen. For the first time, an unlimited number of receivers can individually have access to any individual transponder they wish, from a satellite. (The distributor of the SCDN system is SatFinder, Inc., 6541 E. 40th St., Tulsa, OK 74145; 918/664-4466.)

We recognize this description of the SCDN system is very abbreviated. However, the amount of hard data available describing the system's operation is minimal at this time because of the patent right concerns of the developers.

AT THE RECEIVER

Seemingly the receiver would be the "key item" in the receiving system. While it is true that you must have a reasonably good performing receiver in the installation, there is perhaps less opportunity for you as an installer to do something wrong with the receiver than there is with other segments of the system.

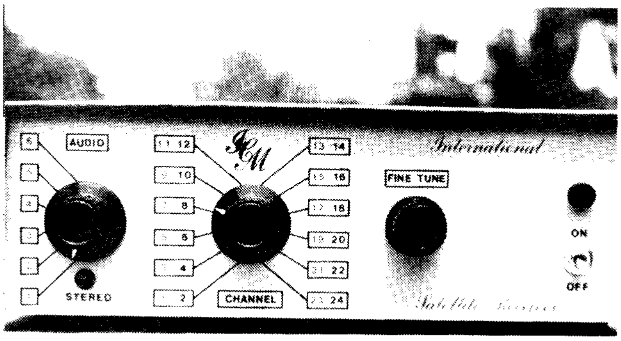
No two receivers are alike. That does not mean that an ICM is different than a Washburn/Earth Terminals; although of course they are different. What it really means is that given today's level of manufacturing expertise no two receivers, even of the same brand, model, and period of manufacture, are going to perform in the same manner. This is a negative statement about receiver repeatability in case you are wondering what it means.

Generally speaking there are three types of receivers available to you:

1) The ultra cheap "basic" receivers, typically under $900, which do in fact receive satellite video and audio but which also lack many of the refinements that most viewers expect.
2) The slightly higher priced ($900 to $2,000) "private terminal receivers" which are available in many formats from perhaps 15 or more suppliers, embodying the basic must-have receiver segments plus enough refinements to make their final (viewing) product of reasonably high or very high quality.
3) The considerably more expensive "professional grade" of receivers, designed for un-attended operation by cable TV systems and broadcasters where emphasis is on the final picture quality; costing up to $10,000.

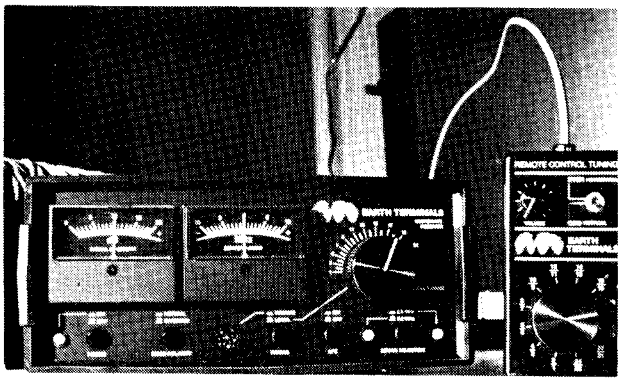
There are two ingredients in the picture quality business. One is sensitivity; the ability of the receiver to produce reasonably high quality video under situations where the signal level is simply weak. The other ingredient is picture clarity, or detail/color purity. It is a very difficult thing to grasp or accept...but, the two almost never go hand in hand in the same receiver. You can have good sensitivity (i.e. the ability to reproduce a picture that you can watch and enjoy), or, you can have great high definition video ("studio perfect"). In dozens of receivers carefully tested to date, we have not seen one that offers both. And that extends from the most expensive $10,000 Intelsat jobs to the $700 'basic' receivers.

A practical example. We keep an ICM 4200 receiver on hand because of *all* receivers we have tested, it produces a better 'weak level picture' than any other receiver we have ever used. When the signal is so weak as to be in the 3 to 6 dB carrier to noise (CNR) region, the 4200 unit will drag the signals out of the noise, and let you watch them, better than any other receiver ever tested.



ICM receiver has outstanding low signal level (below threshold) sensitivity but suffers with video processing distortion at higher signal levels.

However, when the CNR gets up into the 6 plus region we quickly dis-connect the 4200 and replace it with the a Washburn/Earth Terminals receiver or another such as the Teknimat 692A. Both of these are excellent receivers. Both do an excellent job of producing reasonably high quality video (i.e. good definition, excellent color) with what normally be called "below threshold" pictures (those that are under the receiver noise threshold point). But, both have a "window" where they work best; in this case it begins at around a 6 dB CNR and extends up to the threshold point (typically around 8 dB CNR).



EARTH TERMINAL (Washburn) receiver has excellent sensitivity for a receiver that also produces high quality video; but sensitivity on very weak signals is less than ICM unit noted in text.

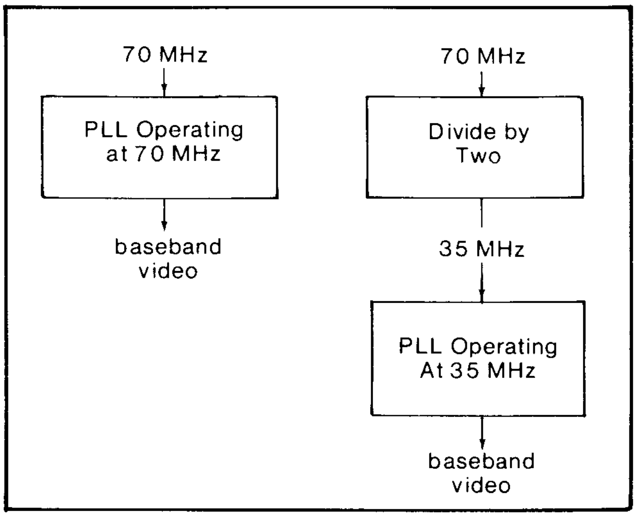
So what happens to the ICM 4200 when the signal level gets up into the 6 plus CNR region? Why do we take it out of line?

The 4200, like many of the phase locked loop detector family receivers, gains its sensitivity by trading off picture definition ability. The phase locked loop method of detection is excellent for weak signals; but at slightly higher CNR regions the loop has a difficult time handling all of the video information (i.e. "sidebands") present. The picture quality begins to tear, around the edges of objects on the screen, and becomes ragged. Sharp color transitions (or contrast transitions in black and white) "smear" or "tear" on the right hand edge. The picture develops a case of the "jitters", which it may *not* have a *weaker* signal level.

If that is comprehensible, what follows may not be.

A PLL detector scheme is a very delicate animal. The operating frequency of the "loop" plus the input (voltage/ signal to the loop must be optimized for each individual PLL detector. This is done of course at the factory by ICM and the myriad of other receiver manufacturers using this PLL technique. However, several things happen to this optimizing of the loop between the factory test bench and your location. In transit the tuning controls get bumped about a bit. When the unit arrives and is plugged into your system, it is operating in a different environment than when it was on the test bench at the factory. In short, it is almost certain *not to work as well* in your hands as it did on the factory test bench. And this says that with virtually any PLL type receiver, you must be prepared to do some on-site "tweeking" to optimize the receiver's performance at your location.

Until the middle of the fall in 1980, PLL receiver sytems operated directly at the common 70 MHz "low" IF range. That is, the PLL loop functioned at a 70 MHz 'center frequency' and the "detection" from the 70 MHz frequency, to baseband video, took place at 70 MHz. Subsequently however, Sat-Tec and then ICM and the others began to utilize a new scheme for PLL detectors; the 70 MHz IF was fed into a "divide by two" circuit which "halved" the 70 MHz (to 35 MHz) prior to detection. This was a significant advance for PLL detectors since the commonly employed PLL devices were operating at the very upper end of their capabilities at 70 MHz. By halving the input (70 MHz IF) signal frequency, the PLL was able to function more normally and with typically better results.



With the divide by two approach, some of the PLL receivers *began* to lose their "PLL tear/ragged edge" traditions. ICM brought out a new version of their 4200, and called it 4000. This unit seemed to have the advantages of the PLL low signal level sensitivity while the picture quality was certainly improved from the previous PLL ragged-edge-look.

Understanding some of the recent history in this field is important because it places you in a position to better understand why some receivers "appear" to work better than others, under some conditions.

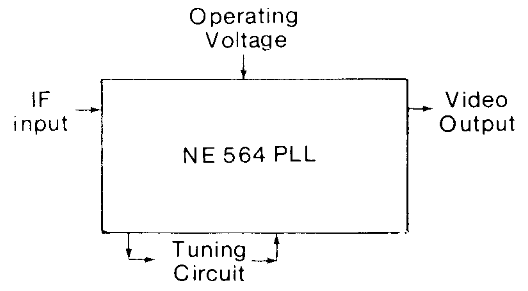
DETECTOR VARIATIONS

Although the satellite signal goes through many stages before it arrives at the detector, we'll start at this "back-end" point because understanding how detector variations impact on receiver performance is key to understanding the full receiver.

Like virtually every other step in the receiving chain (starting with the antenna reflector surface), the detector is important and essential. The detector is a transition stage; it "translates" the radio frequency energy that comes into our system in the 4 GHz region to something we can see; video. And audio.

A detector works by responding to the modulation information present on the carrier. It "senses" modulation, and extracts the modulation from the carrier. There are several ways of "sensing" frequency modulation and most are found in one receiver or another. The Phase Locked Loop (PLL) has already been touched upon. It was first developed for video detection in the satellite service by English TVRO experimenter Steve Birkill; along about 1976. The PLL is actually a "mini circuit" all to itself. It comes in a completely encapsulated rectangular plastic chip with a dozen or more metal "feet" sticking out along its long sides. Each of the "feet" connect to some segment of the electronic circuit buried inside.

A PLL is almost a complete "receiver". If you feed the input signal (the IF range signal) into one "port" and a set of voltages into a couple of other ports, you can then place an external tuning device (capacitor) across yet additional ports and receive detected modulation from a final port. In the process of detecting or demodulating an input signal, the PLL also generates a signal internally. This internally generated signal is a key part of the detection process and in some early receiver designs special care had to be taken to keep the internally generated signal (operating at 70 MHz at the time) from radiating away from the circuit and causing interference with other segments of the TVRO receiver.



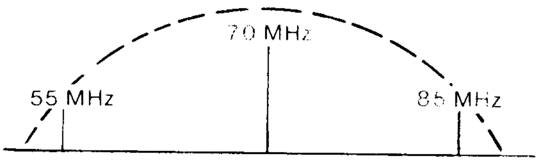
BASIC PLL DEVICE IS MINIATURE "RECEIVER".

PLL devices commonly employed for this application have a maximum useful frequency. That is, as a receiver, they function to some maximum frequency and then their performance starts going down hill just above 70 MHz. And that brings up the first problem for PLL receiver designers; the selection process of the PLL devices.

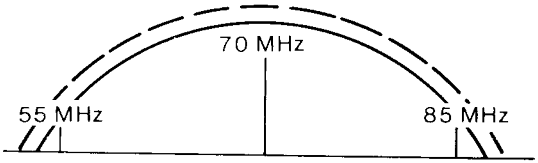
If PLL devices commonly employed start to fall apart just above 70 MHz, it is obvious that you don't want one in your receiver that has this characteristic. If the PLL simply "quit", the degradation would be fairly simple to spot; the receiver would not play or it would play very badly. Unfortunately, many PLL devices don't quit, they slowly go "down hill" as the frequency increases. And if the IF is "centered" on 70 MHz, then we have useful and detectable FM "sideband information" extending above 70 MHz; in fact it is likely to extend from at least 58 MHz on the low side to 82 MHz on the high side.

Now what happens to receiver performance if the PLL slowly begins to degrade (i.e. no longer work **properly**) above, say, 72 MHz? Well, that portion of the FM sideband energy contained inside of our IF passband that falls above 72 MHz (in our example) is simply not detected properly. It is not lost, totally, but it is reduced in amplitude or strength. The output of the PLL, the video baseband information, is 'sloped' or 'tilted' with more information on one side (the low end) than on the other side (the original-in-passband "high" end).

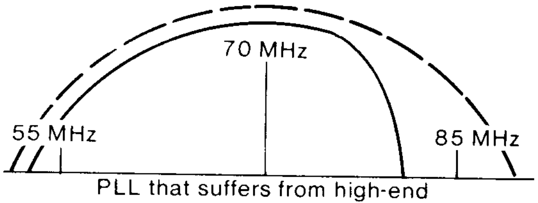
In the real world of tuning and using a receiver with this problem the picture looks "soft", lacking sharp detail and possibly contrast. The ragged appearance of the video usually accentuated with this condition. The picture jitters a lot.



Basic 70 MHz IF Curve



Ideal PLL Response Curve



PLL that suffers from high-end roll-off, response curve.

The solution is to replace the PLL detector with one that **will work** over the full IF bandwidth. Or, as many manufacturers did in the fall of 1980, reduce the PLL operating frequency (by half).

As sensitive as the PLL can be, it is a difficult animal to tame. Between the "high end cut off" found with many PLL devices, the exact center tuning required for the PLL operating frequency (set with an external tunable capacitor or trimmer), and the sensitive nature of the PLL when it comes to setting its input (IF) voltage level, the PLL has many operating habits that are not desirable.

It is no wonder, then, that some receiver suppliers have opted to remove the PLL and to replace it with something else. There are several ways to go here. One will surprise you; it is simply a precisely cut (i.e. tuned) piece of **coaxial cable**, rolled up and stuffed into a sub-container! Two of the more popular receivers using this approach are AVCOM and McCullough Electronics (Vidiark). This "detector line" approach is excellent because it provides very uniform detection "linearity" across the full IF bandwidth. If you have ever marveled at the high quality picture definition on an AVCOM receiver, you are really pleased with the way a precisely tweeked hunk of coaxial cable and the attendant video amplification circuits perform! If this is such a neat "scheme" why don't more people use it?

Well, the cable detector approach is not high on detector sensitivity. There are ways to balance this; add a better balance of input signal to the detector in the IF amplifier stages ahead of the detector, and, be very careful with the video (baseband) amplifier stages following the cable detector.

The shortfall of the "cable detector" system is not insurmountable of course; the high performance receivers now in the field attest to this fact. Most of the designers using this approach do so because it is:

1) Inexpensive
2) Not critical to align (there is **no** alignment procedure)
3) Stable under shipping and temperature extremes.

Still another approach to detection is the video version of the audio detector scheme found in most FM radios. This is usually called a "conventional discriminator" although in truth there are numerous ways to do it. They all use coils and capacitors to detect the "ratio" of the modulation present and having done this extract the modulation information. This approach is a circuit designer's delight since very small changes in parts values and tuning can make a substantial difference in performance. However, once the particular circuit variation is optimized and the parts values chosen this is usually a very stable and high performance system. Like the cable section detector, this approach is not particularly sensitive and requires substantial amounts of before detection and after detection amplification.

Your concern is that any receiver **you elect** should employ **a mature** detection system, regardless of the particular approach employed. Mature means that the designer has taken time and care to optimize the particular system for the best performance he can achieve with that design. Generally speaking you can expect:

1)**PLL** - Excellent sensitivity to below threshold signals, slightly sloppy to plain sloppy performance **immediately below threshold**, fair performance (lacking in high definition display and perhaps with ragged right hand edges on color/contrast transitions) with strong signals.
2)**"Cable Detector"** - Excellent high definition performance, fair to good performance immediately below threshold (minus 1 to 3 dB) **provided** gain to detector and after detector has been optimized; poorer performance on signals more than 2 or 3 dB below threshold.
3)**"Conventional Discriminator"** - Very good to excellent performance on threshold and above signals, moderate noise on signals immediately below threshold; poorer performance on signals more than 2 to 3 dB below threshold.

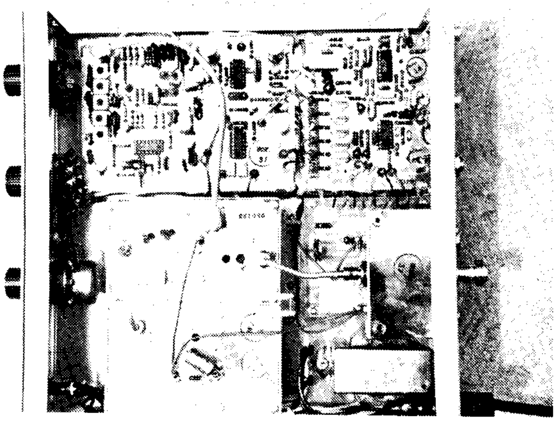
You do not of course select receivers based solely upon their modulator scheme. There is much more to the receiver than this particular segment.

RECEIVER FORMATS

All receivers operate in the 3.7 to 4.2 GHz range. A GHz is 1,000 ,MHz so another way of saying this is that the receivers cover 3,700 to 4,200 MHz. MHz is short for mega-hertz while GHz is short for giga-hertz.

These are very short wavelengths. So short that normal wiring techniques found in lower frequency receiving equipment will not function properly here. At a lower frequency, a short length of wire is simply that; a length of wire. At these very short wavelengths, a short piece of wire can be an accidentally tuned circuit. For this reason most of the parts and sections of the receiver, operating directly in the C band frequency range, are "printed" onto special circuit boards. Receiver design in this frequency range will not tolerate sloppy practices.

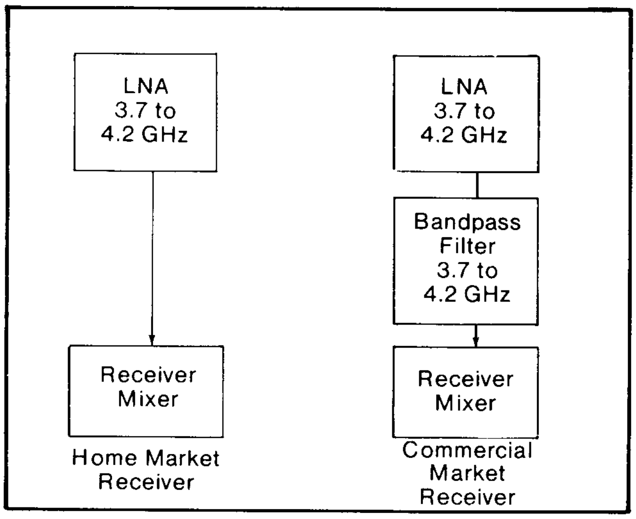
Neatness is not a passion; it is essential if the circuit is to perform at peak efficiency. This is one of the reasons why receiver designers want to transfer the incoming C band frequency range to a lower frequency range as quickly as possible; to reduce the opportunities for error.



NEATNESS IS NOT A PASSION - it is absolutely essential if the microwave video receiver is to perform at peak efficiency. Modular construction of ICM model receiver shown.

There are two approaches to designing the 3.7/4.2 GHz "front end" on a satellite receiver. The commercial people take one of these, at some additional expense, while the private terminal designers take another. Most of the commercial receiver designers feel that the first stage the incoming signals should see is a filter; a bandpass filter designed to allow 3.7 to 4.2 GHz signals through, and to stop other nearby frequency ranges from gaining access to the receiver proper. This would normally be a powerful argument, but the LNA enters our picture.

The LNA is, by design, a filter of a sort. The amplifier stages found in an LNA are tuned to the specific frequency range we wish to cover. This means they accept and pass (with amplification) signals in the 3.7 to 4.2 GHz region, and they reject (with varying amounts of rejection) signals outside of this passband region. In our application, the LNA is an "extension" of the receiver; it operates in the same frequency band and while it may be separated physically from the receiver by a length of cable, it is really an integral part of the receiving unit.

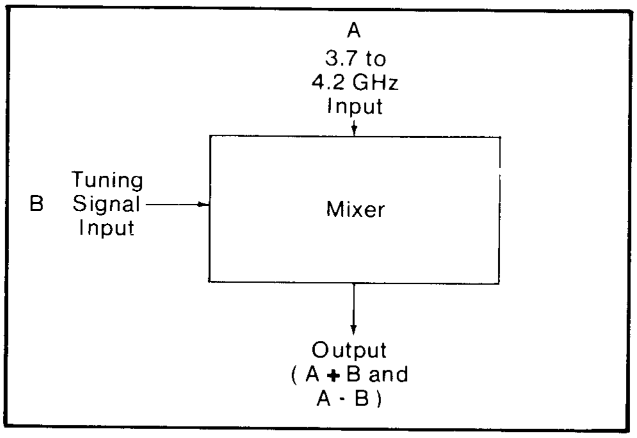


The private terminal designer looks upon the LNA as his "filter", as well as the "front end gain portion" of the receiver. And he sees no need for the input bandpass filter which the commercial designers include as a matter of course.

Following the bandpass filter (that is not there), the receiver designer plugs in a mixer circuit. Now a mixer is the business part of a frequency conversion stage. It accepts two separate input signals, **one of which** is the 3.7 to 4.2 GHz region. The second input is a tuning signal generated internally in the receiver. The mixer literally "mixes" these two signals together and internally, inside of the mixer circuits, **two new frequencies are produced**.

The mixer is a sum and difference circuit. When you feed two separate signal frequencies into it, they come together and mix together. If one is "**A**" and the other is "**B**", internally in the mixer they become also **A+B** and **A-B**. "A" here is assumed to be the higher (greater) of the two frequencies.

At the output of the mixer, we then have two new products. Neither "A" nor "B" make it to the output, thanks to some special designs in the mixer. But A+B and A-B do. Now let's assign some numbers to A and B.



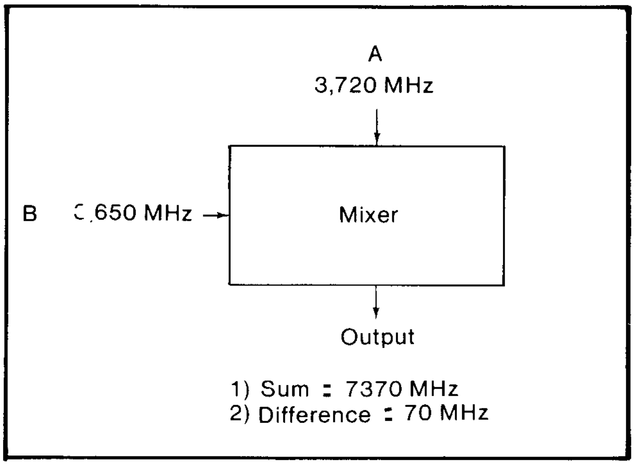
We'll allow A to be the whole spectrum from 3.7 to 4.2 GHz. And we'll allow B to become a **tunable frequency** created inside of the receiver covering 3.63 GHz to 4.13 GHz. We'll connect a knob to the tuning control for B so we can conveniently tune the frequency range with this signal source. Finally, we'll call the signal source by a special name; a "VCO" which stands for voltage controlled oscillator.

Now we'll take the tuning knob connected to the VCO and we'll adjust it, until the signal coming out of the VCO and going into the mixer is operating at 3.65 GHz (3,650 MHz). That's "B". Also present in the mixer, coming in from the antenna jack that connects us to the LNA, is the **whole band** of carrier frequencies making up the satellite signals. One of these, transponder 1, has a carrier frequency of 3,720 MHz. Inside the mixer we have 3,650 and 3,720 MHz. The **sum** of the two is 3,650 + 3,720 or 7,370 MHz. That frequency now appears at the output of the mixer. However, the **difference** of the two is 3,720 - 3,650 or **70 MHz**. And that frequency also appears at the output of the mixer.

In the mixer circuit, then, we have managed to reduce the effective operating frequency of transponder 1 from 3,720 MHz to 70 MHz by mixing it with a VCO carrier at 3,650 MHz.

What we have just described is a single conversion receiver; one that accepts the 3.7 to 4.2 GHz input frequency range and converts that range, a single channel at a time, down to a much lower IF (intermediate frequency) for further signal amplification, filtering and detection. The format described is very similar to that employed by AVCOM, KLM, or Vidiark, for example.

Now this is **not** the way TVRO receivers have always functioned. In fact, "single conversion" receivers were frowned upon until June of 1980 when an Arizona engineer named David Barker created a technique to make them function reliably.



Prior to "single converions" there was (and still is) double conversion. Here is how it differs from the single conversion receivers.

A double conversion receiver has **two** mixers. It takes the C band satellite signals down in frequency **first** to a higher IF; typically in the 1,000 to 1,300 MHz region. It does this by selecting a VCO carrier frequency which is sufficiently removed from the 3,700 to 4,200 MHz input range so that the difference equals not 70 MHz but let's say 1,200 MHz. If 3,720 MHz is the transponder 1 carrier frequency, and our "high IF" will be 1,200 MHz, then our VCO will have to tune to 3,720 - 1,200 or 2,520 MHz to create a "difference frequency" of 1,200 MHz. Once the signal is reduced in frequency to 1,200 MHz it is amplified, filtered (to remove adjacent channel signals) and then it is frequency converted a second time. **Now** our input frequency is 1,200 MHz, and if our desired output frequency is 70 MHz (our "low" IF), then the VCO operating at 1130 MHz can be "fixed"; that is, it will not have to tune since the input is always (centered on) 1,200 MHz, and the output is always (centered on) 70 MHz.

Now why would somebody do something twice **if once was all it took to get from start to finish?** Arguments abound on this point in the receiver industry. The basics are as follows:

1)**Double conversion** uses more parts, and costs more. Alignment of a double conversion receiver is trickier and there is more to get out of whack during shipment.

2)**Single conversion** suffers because the VCO is operating in or immediately adjacent to the input band of interest; 3,700 to 4,200 MHz. The VCO signal is therefore both a conversion section primary part, and, **a source of interference** for other signals inside of the band of interest. Only, it does **not** interfere with the receiver it is operating inside of; only with other receivers that may be connected to the same LNA/antenna.

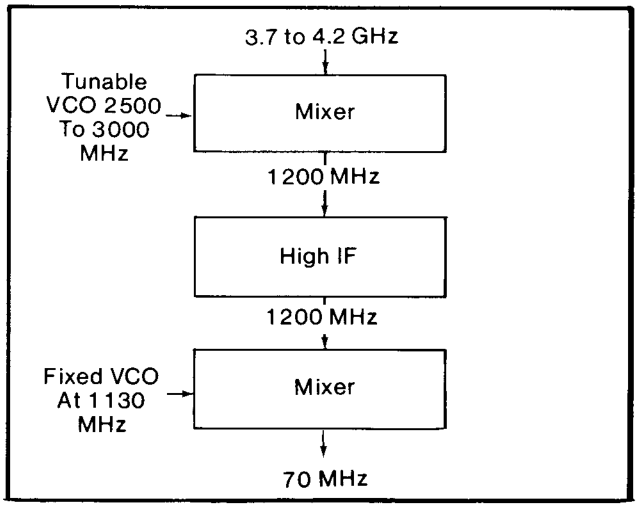
Double conversion, **in theory**, should provide slightly greater stability (i.e. you touch up the dial less often to keep a signal properly tuned in), better selectivity (less interference between adjacent carriers), and a slightly better video picture because of improved system signal to noise performance. **That's theory.**

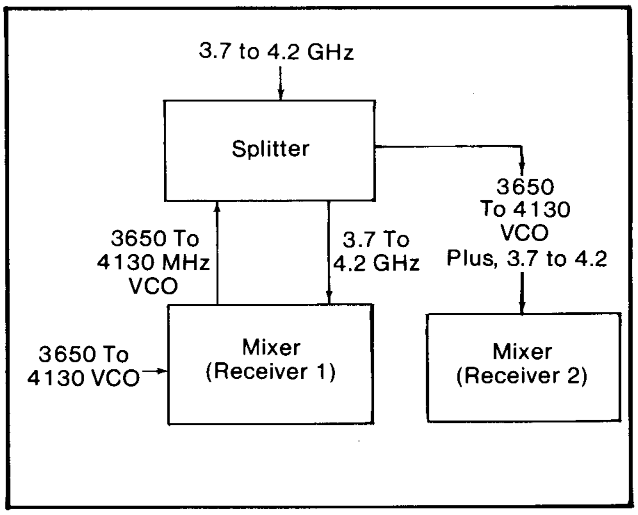
In practice there are so many little tricks the receiver designer can play with the receiver detector, to hide shortcomings in the balance of the receiver, that in the real world the single conversion receiver **may be** as good as or better (in terms of performance you can see on the screen) than the double conversion receiver.

Which leaves us, really, with only one true strong argument for double conversion and against single conversion; the problem created by having the VCO "in band", or operating close to the actual incoming carrier frequency (only 70 MHz removed).

Because the mixer in a single conversion receiver cannot "tell the difference" between the incoming 3,700 / 4,200 MHz satellite signals, and the receiver created VCO signal that typically tunes from 3,650 to 4,130 MHz, the VCO signal ends up going backwards, out of the antenna input port, towards the LNA. If there are line splitters along the way, connecting up two or more receivers to the same antenna, then the VCO signal from the **first** receiver ends up mixing in with the incoming signals from the LNA and going to the **additional** receivers. There it presents a much more powerful carrier to the other TVRO receivers than the satellite signals, and it will literally wipe out several channels of reception. And since the VCO is tuned, as the first receiver operator changes channels, this interference then "moves around" the band; wiping out first one transponder and then another transponder.

If the installation in question will have but a single receiver, ever? Then you can forget about this part of this concern and select your receiver system based upon other parameters.

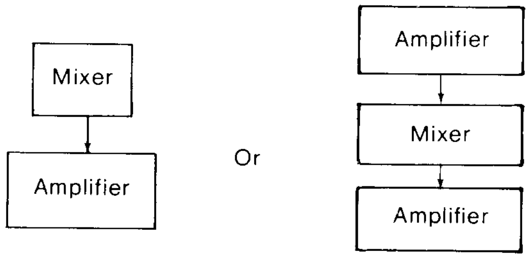




Now **is it possible** for a single conversion receiver, connected to one TVRO antenna, to cause interference to **another TVRO receiving system** some distance away? Unfortunately, the answer is yes, although hard numbers are difficult to come by at this time. At most of the recent SPTS events, where dozens of antennas are crammed into a tight or small area, there has been considerable interference created by too many single conversion receivers operating in the same physical area. For now, let's leave it like this. **It is possible**, given the (in)correct circumstances, **for one private terminal to cause interference to another private terminal.** What is unknown at this time is how close together the two terminals must be before this interference happens, and what steps might prove useful in reducing or eliminating this interference. Oh yes, this applies to the single conversion receiver systems **only.**

RECEIVER AMPLIFICATION

After each mixer stage the receiver must amplify the new frequency of the satellite signal. This could be at a high IF, or it could be at 70 MHz. Most receiver manufacturers prefer to do the bulk of their amplifying at the **lowest** frequency range; 70 MHz. The double conversion receiver designers are forced, however, to iclude **some** amplification at the high IF region as well since a stage of "mixing" is a stage of signal loss (i.e. a mixer loses signal in the mixing process).



TO MAKE UP FOR SIGNAL LOST IN MIXING PROCESS, GAIN (AMPLIFIER) STAGES MUST FOLLOW AND/OR PRECEDE MIXER.

Gain is rated in dB, just like with the LNA. Most receivers require between 70 and 80 dB of gain, **within the receiver proper**, to turn the LNA delivered signals into a useful picture. Most of this gain, in all receivers, is found at 70 MHz. They get this gain using either descrete stages of amplification (**each** stage has its **own** transistor), or by using "gain blocks"; pre-wired mini circuits that simply plug into the circuit board.

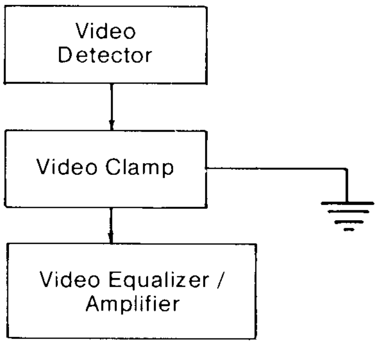
The final stage of amplification is found in the video section fo the receiver. A fairly standard published specification calls for the receiver to deliver 1 volt peak to peak of video baseband voltage out of the receiver. This is a compatible amount of voltage to plug directly into a modulator or baseband monitor.

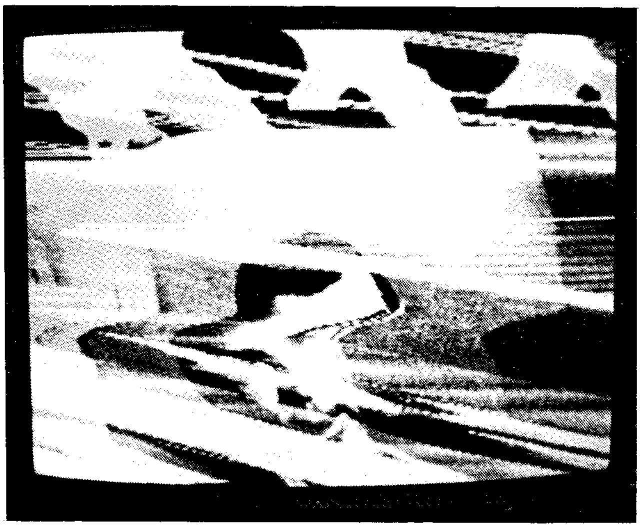
VIDEO PROCESSING

The video signal that comes out of the **detector** is not suitable for viewing. Most US domestic satellite operators add to their uplink signals something called "waveform / energy dispersal". This is an extra signal, applied to the uplink transmitter, which effectively "spreads" the signal out over the full transponder. And this prevents it from being concentrated in any one spot. This energy dispersal waveform is actually a 30 hertz signal. Your AC line current is a 60 hertz wave so you can see this is a pretty low frequency.

The 30 hertz waveform must be "stripped" away from the video waveform before you view it, or you get a pumping kind of action with the video; alternating black and white bars interlace with the picture. The 30 hertz is simply disposed of, in most receivers, by running the video through a device called a "clamp". A clamp looks at the 30 hertz signal and carries it via a shunt circuit to ground; effectively killing it.

You can build a clamp with a transistor or two, or you can use a single 75 cent part called a diode (this is, as diodes go, slightly more elaborate than most). Designers go both ways, although most private terminal receiver clamps are simply diodes shunting the 30 hertz waveform to ground.





WITHOUT A CLAMP to shunt to ground the 30 hertz energy dispersal waveform, video picture could look similar to this. Clearly not suitable for viewing.

Some however have gone an extra step, recognizing that in the video processing stages it is possible to correct **some** of the built-in limitations placed on the video signal by either the uplink operator, or the preceding receiver stages. Some of the newest receiver circuits, such as the Teknimat 692A, are starting to "sample" the quality of the video on a line by line basis. Since the television picture is made up of approximately 500 lines of individual picture elements, it is possible to analyze each line and to determine whether an individual line has "blemishes" present; such as might be caused by noise in the signal. Having determined that there are blemishes, the next trick is to replace the blemishes with suitable replacement picture elements. One way to do this is to look at a line that has blemishes, eliminate it electronically if the blemishes are bad, and then electronically **replace** that line with a **substitute** line. Some of the more elaborate video processing equipment available in other similar fields replaces a "bad line" with a line from immediately above. To the eye, since the lines are so close together and picture changes are seldom abrupt across a single line, you never even know you are looking at a re-constructed picture.

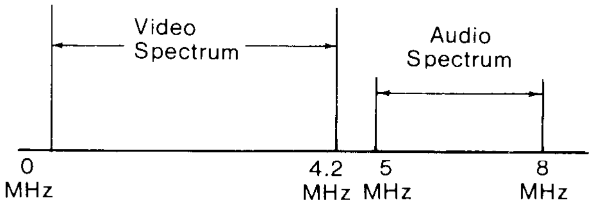
TVRO receivers are not to this stage, **yet**, but this is coming. It turns out that it is far simpler(i.e. less expensive) to do some "fix up work" with the satellite video signal **after the detector than it is to try to make the first portion of the receiver more sophisticated.**

AUDIO PROCESSING

You will recall that our video is frequency modulated. You will also recall that our audio is **also** frequency modulated (FM). In the satellite field the audio is transported from the uplink, through the satellite, to your receive terminal as a "subcarrier". A subcarrier is an "extra" carrier, or signal, separated from the main carrier which transports the video modulation.

At the uplink transmitter, and at the output of your TVRO receiver, the video information occupies "baseband" from approximately "0 MHz to 4.2 MHz". It is a mini-spectrum to itself. The frequency modulation spreads this baseband signal out, for transportation, to a wider spectrum. Now since the **video** information baseband spectrum "stops" at around 4.2 MHz, it is possible to add in some additional information (modulation) if the added information functions on a frequency **higher than** the video information.

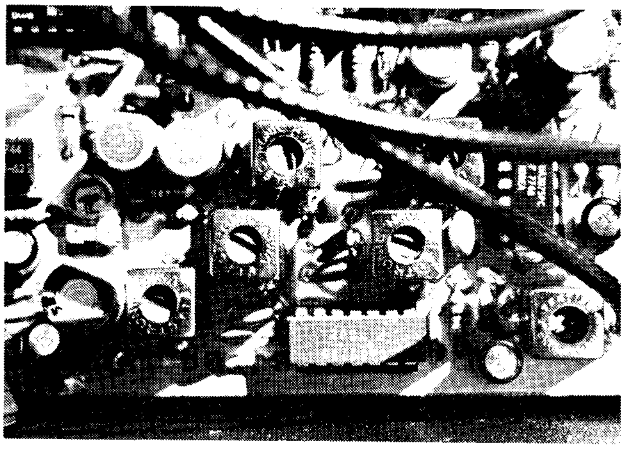
At the uplink, additional carriers are created. Typically, they will be on 6.2 or 6.8 MHz although in practice, worldwide, **any frequency** between roughly 5.0 MHz and 8.0 MHz can be used for this purpose. In fact, several can be generated and carried along with the video signal. Russian Ghorizont transmissions often carry as many as four separate "audio subcarriers", one dedicated to each of four languages that may accompany the video program.



AUDIO SUBCARRIERS ARE PLACED HIGHER IN FREQUENCY THAN VIDEO, TYPICALLY BETWEEN 5.5 AND 7.5 MHz.

At the receiver, the "higher-than-video" subcarrier frequencies are present through the full receiver, right down to the output of the detector. There, using special combinations of low and high pass filters, the audio subcarriers are finally separated from the video. They are sent to a second detector, one that is specially tuned to extract their audio information from the frequency on which they operate; 6.8 MHz for example.

Some receivers supply a **tunable audio subcarrier detector.** This is actually a small FM (audio)receiver that tunes from, say, 5.5 to 7.5 MHz and as you tune the knob you are tuning through that frequency range "searching for" audio subcarriers. Others supply two or more "preset" audio subcarrier outputs and a panel switch that allows you to select which one of the preset subcarrier frequencies you will hear.



SLUG TUNED FORMS are often used to tune audio circuits/discriminator for desired sub-carrier. Sat-Tec receiver illustrated.

Most fixed-tuned (preset) audio subcarrier detectors have a trio of adjustments, slug tuned forms, which you tune to place the individual module (circuit) onto the appropriate subcarrier frequency. Two of these tune the detector to the proper carrier **frequency** (i.e. 6.8 MHz) while the third tunes the detector proper for best audio detection. If the sound is raspy or crackly on a receiver you have, first isolate the appropriate subcarrier module. Then select a plastic tuning tool that matches the small grooves on the tuning slug, and **very carefully** tune the three slugs, just a half turn or so at a time, for improved audio. Two will tune quite broadly (the frequency determining circuits) while the third will be quite sharp (the detector). The frequency tuning circuits must be **peaked first**, before the detector slug is adjusted for most natural sounding audio. It is best to do this when music is being transmitted since the wide range of audio frequencies present, with music, is the true test of the proper adjustment of the **detector** slug.

THE MODULATOR

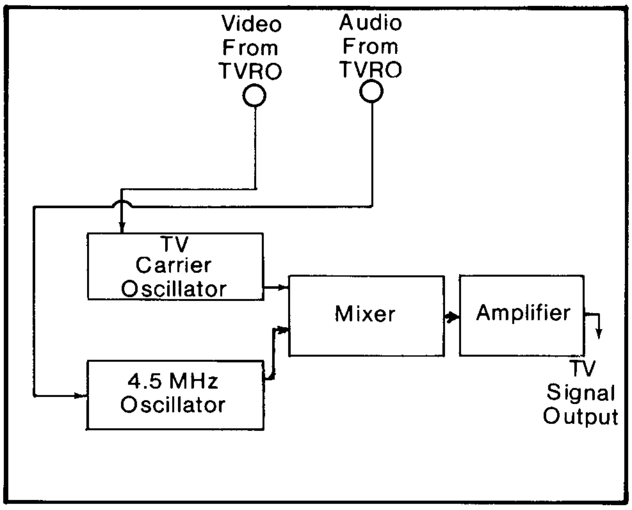
What leaves the basic satellite receiver is raw video and raw audio. The audio can be listened to on earphones or even connected to a speaker system. The video can be viewed on a "video monitor"; a television set without a tuner. The same kind of box you see used in TV studios for camera and signal monitoring.

Unfortunately most people do not have monitors in their homes. So the answer, after we have gone to all of this trouble to get the frequency modulated satellite signals into our homes, is to process them **one more time** so that a standard television receiver can tune them in.

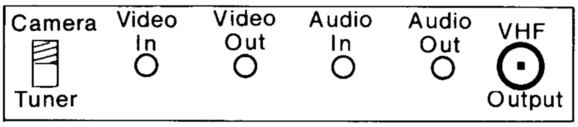
We do this with a small device called a modulator. A modulator is really a very low power television transmitter. It accepts video and audio input, and it uses that video to amplitude modulate (AM) a new carrier frequency which can be tuned in on a "standard" television receiver. It takes the raw audio and uses that to frequency modulate a separate (sub)carrier which can also be tuned in on a standard television receiver. Thus the modulator is an interface, that transfers our baseband video and audio back to a format which we can use without special monitoring equipment.

More than half of the private terminal **receivers** do not have a modulator. That is up to the user to supply. There are numerous reasons for this, including a little known FCC regulation which requires that any system with a "**built in modulator**" must go to the FCC Laurel, Maryland Labs for "type approval" **before** it can be offered for sale. Very few TVRO receiver manufacturers are willing to tie up a complete receiver at the FCC for months awaiting "type approval" so modulators, if offered, are done as "separate **stand alone** units".

Modulators are neither complex nor prone to fault. All VCR/VTR machines, all of the new VideoDisc players, for example, have modulators built in. In fact, if you have a VTR and it has video and audio input jacks on the rear (virtually all do), you already have a way to use those input jacks to plug in your satellite TV receiver and thereby utilize your VCR modulator for your satellite reception.



TYPICAL BACK DECK VCR



1)PLACE VCR IN CAMERA-IN POSITION. 2)CONNECT TVRO RECEIVER VIDEO OUT TO VCR VIDEO IN. 3)CONNECT TVRO RECEIVER AUDIO OUT TO VCR AUDIO IN. 4)CONNECT VHF OUTPUT TO TV RECEIVER VHF ANTENNA INPUT, TUNING TV RECEIVER TO OUTPUT CHANNEL OF VCR.

Most of the garden variety modulators available operate on either TV channel 3 or 4; switch selectable. Thus you can select the channel that is not in use in your area. A new generation of modulators is coming on the market however, from several different sources, which are factory set to operate on virtually **any** VHF TV channel. Some are even available for the lower UHF TV channels. Modulator "kits" are available from a number of sources as well.

The primary shortfall of most of the low cost (i.e. under $100) modulators is their low **power** level. Most generate between +6 and +10 dBmV (decibels above one millivolt). That's enough signal voltage to feed one, or perhaps two, TV receivers but hardly enough to wire a full house with TV outlets or to spread the satellite TV signal about the neighborhood.

The solution to this "problem" is to select a higher power modulator; one capable of putting out sufficient RF "signal voltage" to allow you to feed as many TV outlets as you require. We'll look at that shortly.

THINGS YOU CANNOT DO

Not all satellite signals are created equal. We already know that footprint patterns differ, and antenna boresight patterns differ. But what else may vary from transponder to transponder and satellite to satellite?

1)**Not all transponders operate at full power** - While each transponder is rated at 5 watts peak power output, that is a rating which presumes that the transponder is operating in a "like new" condition. Many do not and for this reason they are "backed off" (meaning their power output is reduced). Additionally, to conserve satellite power when no **programming** is being transmitted, satellite operators will often manually "back off" the signal sent to the satellite when a test pattern is being sent out. This makes the test pattern **look** weaker than programming (**it is**).

2)**Not all uplinks operate at full power.** Each uplink transmitter plus antenna would ideally be designed so that the signal arriving at the input to the satellite was just sufficient to produce a full five watt output from the satellite transponder. However many uplinks fall short, for various reasons (portable Robert Wold uplinks are simply too small, for example), and they arrive at the satellite too weak to produce the full five watts of output power. You may notice that one program on a transponder looks great while the next one, from a different location, is filled with "sparklie noise". That's why.

3(**Not all audio subcarriers use common subcarrier frequencies.** While most of the SATCOM and WESTAR transponders rely on 6.2 or 6.8 MHz subcarriers for their audio, there is nothing sacred about these two subcarrier frequencies. The audio can be carried along virtually anyplace between 5.0 and 8.0 MHz, or, it can actually be sent along on a separate transponder!

4)**Canadian** (ANIK-B) **audio sounds funny.** The Canadian system, especially on the English speaking transponders, uses their subcarriers to carry not only the "program audio" but to also carry additional radio network programs. With a **standard** receiver you hear the main (TV program) audio alright, but in the background there is a constant (and annoying) "tinkle-tinkle" caused by the presence of the other (non TV) audio material. You have to add additional audio filters to cure this one. See **Washburn Manual** from STT.

5)**Satellite transmissions via non US/Canadian satellites will not be in color.** Usually. The North American color standards "system" is called "NTSC". That's a technique we adopted to produce color television in the early 50's. Most of the rest of the world opted to do it a different way. Three, primary, different ways as a matter of fact. So when you tune in the French Symphonie satellite or the Russian Molniya or Ghorizont satellites, you have to use a SECAM "standards" color monitor. If you are tuned into transmissions from BrasilSat, you need to view the pictures on a PAL-M (standards) color monitor. Or, alternately, you can tune in color transmissions **in black and white** on a US standards receiver.

6)**Non-US standards baseband signals**, fed to a US (NTSC) standards modulator, will place the signals onto a standard VHF channel all right; in black and white. In NTSC, the color subcarrier is at 3.58 MHz. The color decoder circuits in your NTSC receiver looks for a 3.58 (color) subcarrier, and if present, demodulates the color information. SECAM and PAL standards utilize other subcarrier frequencies, and like the audio subcarrier section of your TVRO receiver, they will not "trigger" the color circuits if they do not match the color subcarrier detector frequency. There is no "easy", as in low cost, solution to this one.

EXPANDING YOUR COVERAGE

There are two primary ways to "share" satellite TV reception.

One is to connect additional TV receivers to your terminal's modulator through coaxial cable; the other is to use the modulator as if it were a low power TV transmitter, amplify the modulator signal level with an external amplifier, and then connect the amplifier to an antenna designed for the modulator channel frequency and radiate the signal around the countryside.

Inside the USA/Canada, the cable distribution technique is the only one that is legal. Well, that is not totally correct. You can, in the US, apply to the FCC for a license in the (new) Low Power TV Broadcast Service, a subject treated in detail in the STT "**LOW POWER TV HANDBOOK**" Manual. Most people with a few neighbors to connect up opt for cable distribution however.

Suppliers of cable TV hardware publish many small guidebooks designed to acquaint you with the basics of **cable** distribution. The subject is big enough that we cannot do it justice here, except to point out what you can and cannot do in a general way.

1)You can...

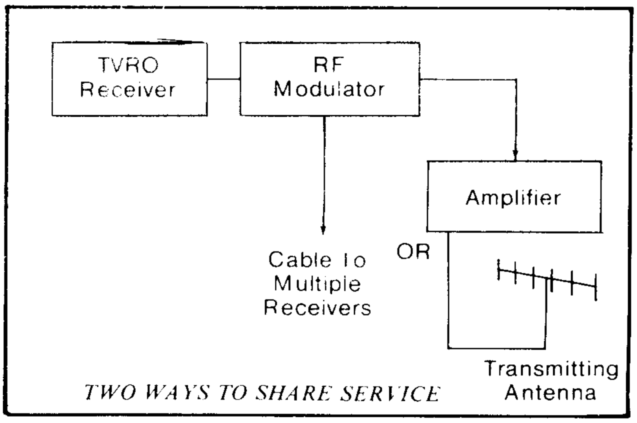
A)**Boost** the standard single channel TV modulator in power, usign off-the-shelf "line" or "single channel" amplifiers. Having done this, you then proceed to run relatively low cost coaxial cable throughout the area where you will connect up other receivers.

B)Individual set locations are 'tapped' into the coaxial cable distribution line using special parts called "tap offs" or "directional taps". These devices extract from the cable line a known amount of the total signal present, just enough signal to insure that the receiver connected to the line through the tap-off device will properly function. Each tap-off dimishes the amount of signal left after that point, by a small amount. And, each foot of cable that carries the signal forward also reduces the signal level present, since all cable has loss. These are known factors, easily calculated in advance, and at some point along the line these "losses" add up to a point where to continue carrying signal further you need to place another "line amplifier" in service. This unit **re-amplifies** the signal again, and you start the process of calculating tap-off losses and cable losses anew from the output of the last line amplifier.

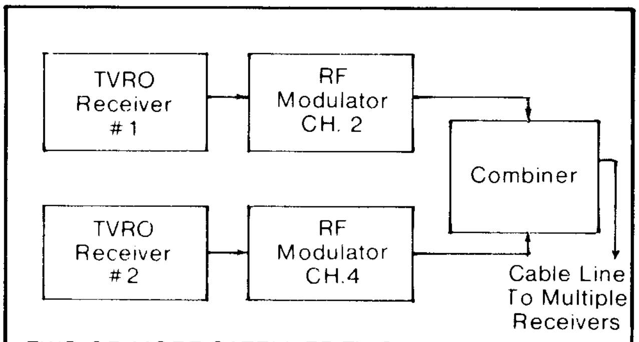
C)If you wish, you may "stack" more than a single TVRO receiver and more than a single modulator. This allows the users of the system to have access to more than a single satellite TV channel at a time; each modulator operates on a different VHF TV channel and each receiver connected to the line simply selects the satellite TV channel desired by tuning to the appropriate cable-fed VHF channel. It should be noted that if the master receiver,dedicated to a single channel, is retuned to another satellite service channel, everyone on the cable distribution line has to accept the new transponder choice.

D)The "cost" of doing all of this varies as a function of how difficult it is for you to run the cable lines. Commercial CATV firms average around $1 per foot ($5000 plus per mile) for **overhead** cable plants installed in uncluttered areas. This includes the cost of the cable itself, the amplifiers, and the hardware. It can be done for about half this price if you are working on private property and extending lines along roof lines and fences. On the other hand, to cable a mile in downtown New York City can easily exceed $50,000.

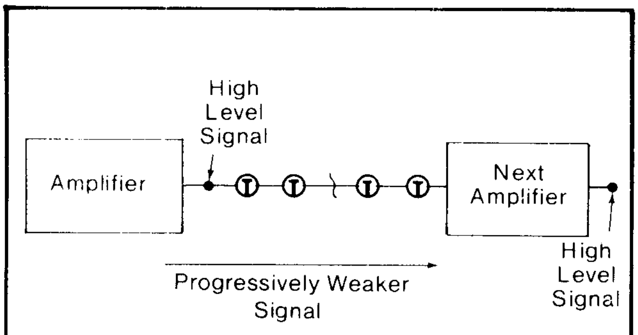
E)A single building, such as a motel, hotel, apartment or condominium, usually is calculated on the basis of so much **per outlet** since the number of cable "feet" involved may be small. You use less cable, but more cable electronics, since your "density" of users is high. A figure in the $50 to $70 per user (outlet) region is usually very close, if you are **adding** a cable distribution system to an **existing** building or complex. If you are going in with the cable prior to the building's completion, $40 per outlet is possible.



TWO WAYS TO SHARE SERVICE



TWO OR MORE SATELLITE TV CHANNELS CAN BE COMBINED ON SAME COAXIAL CABLE USING TWO OR MORE RF MODULATORS OPERATING ON SEPARATE TV CHANNELS.



CABLE AND TAPS WEAKEN SIGNAL, REQUIRING "REPEATER" AMPLIFIERS AT REGULAR INTERVALS.

The most common problem people make with coaxial cable distribution systems is to not spend adequate time studying the basics of the service, and, looking for the **best** way to do the job. "Really cheap" systems, using 300 ohm twin or flat line are to be totally avoided, even for a system within a single house. This is not a complicated area of electronics, but it is quite unforgiving of errors.

PEAKING AND TWEEKING

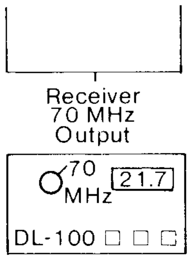
Even if we did not know that receivers often arrive at the final destination "out of whack", there is a genuine human tendency to want to tweek and peak things for optimum performance.

And because the difference between fair results and good results is often just a matter of a dB or more additional input signal to the system, there is always that gnawing feeling that **perhaps** just another nudge on the antenna, or feed, or adjustment in the receiver will bring us home free.

A receiver with a signal strength meter is a handy tool. Unfortunately, many of the meters found on typical private terminal receivers move very "softly" or only when there are relatively large changes in signal level. One of the few that indicates change, accurately, **before** you can see the change on the TV screen with your eye, is the Washburn/Earth Terminals receiver. Others, such as the various ICM units, typically require changes that your eye sees **before the meter changes.**

An instrument that actually **measures** the received signal levels would be a handy tool, if it reacted to small signal level changes. There is one partial tool available, at a fairly reasonable price. It is a CATV grade field strength meter, produced by SADELCO (299 Park Avenue, Weehawken, NJ 07087). The **Digit-Level-100** is a meter which has a digital display of receiver carrier level. It tunes from 50 MHz to 890 MHz. Your receiver (low) IF, 70 MHz, is inside of this range. The problem is getting "at" the 70 MHz signal so that you can in turn display it on the DL-100. Some of the newer receivers produce a 70 MHz IF output, either from an antenna mounted downconverter stage, or in the case of the Washburn, from the remote mounting downconverter unit. Thus you have access, via a connector, to the 70 MHz signal from the receiver. Now, how do you use it?

Remember that our satellite signals are frequency modulated. All terrestrial signals are amplitude modulated. And the DL-100 is designed to work with AM signals. Will it work with FM signals? Yes, but you must be careful how you use it.



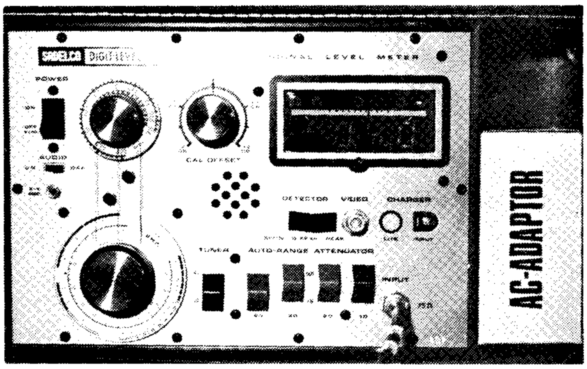
RELATIVE SIGNAL LEVEL CHANGES CAN BE READ ON DL-100 DIGITAL SIGNAL LEVEL METER, AT 70 MHz IF.

First you need to dial up a **constant** video scene. This can be a blank carrier (sync present but no video modulation), or, a color bar pattern. A video scene that is constantly changing will not do since the frequency modulation of the signal will cause the indicated signal level to vary many-many dB in both directions as the scenes change.

Even with a constant video display, there will be **some jumping about** of the indicated signal level. This is one of the reasons why an analog meter (i.e. one with a meter scale and pointer) cannot be used since you cannot "eyeball" the bouncing meter and retain a sense of "better" or "worse" as you adjust the LNA focus point, the antenna heading, and so on. With digital display of numbers, you can at least eyeball and **retain** the "average" of the bouncing **numbers.**

The actual or absolute level measured is of no particular importance. Except, you must note what the level averages when you first connect up the meter, and then whether that "average" goes up, or down, as you make system changes.

Now the FM signal which you are measuring is spread over a fairly wide spectrum; typically from around 55 MHz or so on the low end to 85 MHz or so on the high end. Close to the middle, near 70 MHz, will be the peak or strongest amount of signal. Carefully set the digital field strength meter to the strongest signal level and place the DL-100 in the "Peak Detector" mode. Now go about your tweaking business, reading the changes in signal level at 70 MHz.



SADELCO-100 digital field strength meter can be used with receivers providing 70 MHz IF output jack as highly accurate alignment tool.

Lacking such a piece of test equipment, are there other ways to peak a system? The next best "instrument" is your eyeballs.

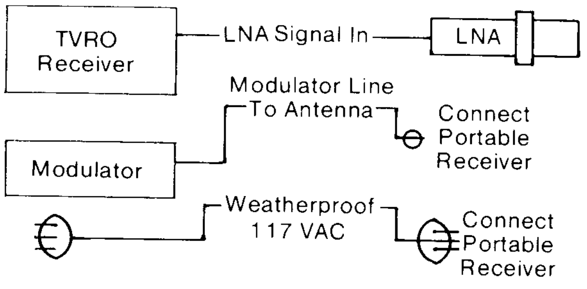
1)Locate a constant video source, such as a color bar pattern.
2)Pay particular attention to the lower right hand portion fo the display; black or shades of grey on a black and white monitor. Notice, by careful study, how many little dots or sparklies there are popping in and out there. Don't bother them; just average in your head how it looks.
3)Adjust, while watching the monitor.

Now we urge you to make your installation so that you can place a monitor **right at** the antenna. For permanent installations, we always run an extra length of RG-59/U (75 ohm) coaxial cable from the receiver location back along the incoming downline to the antenna. At the antenna we install a 75 ohm female F fitting in a small box so that we can plug a monitor into the line when we are doing antenna work. In that way the full TVRO receiver can stay inside, but we have access to what it sees through the "feedback" length of RG-59/U. We also run a piece of TW-12 or 14 for AC power to the antenna pad, and install a weatherproof outdoor electrical outlet box at the antenna.

It is possible, but highly frustrating, for **one person** to watch the monitor while **another person** makes the adjustments. Changes happen very rapidly and I have yet to find a person who can give me clear reports of what is happening. By the time the observer "sees" the change, speaks out loud to me and I understand what has been said, I have gone beyond the "best looking" point. For this reason it is urged that you have a monitor **where the person making the adjustments can see it.**

Once your picture starts to get so good that the sparklies appearing along the lower right hand edge of the color bar are gone, it is time to locate a weaker transponder. Once you reach a "too much" signal point, it becomes very difficult to see changes taking place. As a last resort, use a transponder that has programming (rather than a color bar), but do so very carefully.

While antenna peaking can be done with test equipment, touch up tweeking inside of a receiver must almost be done with the eyeball as a test instrument. Yes, there are fancy video signal to noise test sets around that do a fine job but they are both expensive to acquire and difficult to use for the average person. And the fully automatic test sets that read out digital displays of video signal to noise ratios are still very expensive laboratory curiosities.

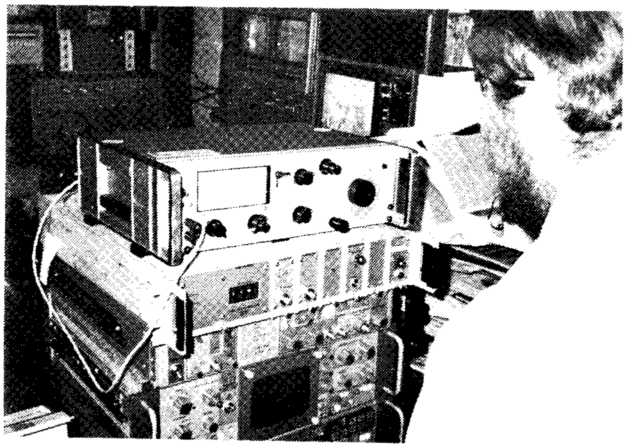

TVRO Receiver
LNA Signal In
LNA
Modulator Line To Antenna
Connect Portable Receiver
Modulator
Weatherproof 117 VAC
Connect Portable Receiver

BY RUNNING FEEDBACK LINE TO DISH. YOU CAN MONITOR PERFORMANCE OF DISH / LNA ADJUSTMENTS DIRECTLY AT ANTENNA.

Before you take the cover off your receiver, be **very certain** that you have on hand printed information from the manufacturer telling you what **can** and **cannot** be tweeked. ICM, Sat-Tec and a handful of others will supply this information. Others, such as AVCOM, do not suggest you do anything inside of the receiver.

Most of the tweeking adjustments will depend upon the receiver design philosophy. PLL receivers have one or two PLL related adjustments that must be optimized for best performance. Non-PLL receivers have no such "detector" adjustments. Double conversion receivers have bandpass filter adjustments for the high IF region (Sat-Tec for example); however they are extremely touchy to re-peak and fortunately seldom (if ever) require attention. Single conversion receivers have no eye-ball tweeking filter adjustments you can make.

Many receivers allow you to adjust the two or three adjustments that go with properly centering the tuning on audio subcarrier detectors; a subject already covered. Most also have a **pot** to adjust the **video output** level. The video output level will be proper when it is around a volt peak to peak; you almost need a "scope" to set this on the money. Fortunately, the modulator that follows the video output is quite tolerant of this **exact** level and anything **from** 0.5 volts **to** 1.5 volts is usually in the right "window" for proper modulation performance. Therefore, you can observe the video contrast and quality on your TV receiver with a standard broadcast signal, switch to the satellite modulator and if the contrast/color level seems low or high by comparison, simply increase or decrease the receiver video output level pot until the two (off air and satellite) seem to **look** about the same.



IT TAKES around $20,000 in high precision test equipment to measure accurately received signal to noise ratio at video baseband.

FINALLY - FINDING THE FIRST BIRD

Very little is as frustrating as **not** finding the first bird. There are many "foolproof" techniques around; I'll share mine with you.

1)Determine, from a computer run or calculation, exactly **how high** in the sky the geostationary/Clarke orbit belt is for your location, **due south of you.** This will be a "number", such as "50 degrees elevation". This would be the elevation of a bird that was on the precise same latitude as you.

2)Align your dish **mount** so that it is, as closely as you can calculate, running "**true** north by true south".

3)Adjust your elevation all threads, jack screws or whatever so that your dish has an elevation when pointed due south that matches the geostationary orbit belt heading for your location.

4)Check to be sure your polarization control rotor is set for true horizontal or true vertical. Not in between the two.

5)Set your TVRO receiver to come to some mid-band channel such as 12.

6)Slowly bring your antenna away from due south, to the bird that is closest to due south for you. You do this with the east/west or azimuth control. **Leave the elevation control alone.**

7)COMSTAR D3, which seldom carries video, is closest to due south for many fo us. You will notice crazy, waving lines on the screen or a change from black and white sparklies to a smooth grey screen as you run across D3. If some other bird is closer to due south for you than D3, fill in the appropriate bird parameters, adjusting to horizontal polarization if a WESTAR or ANIK bird, and setting the receiver to a known active transponder on the bird closest to your due south.

8)If you have only moved 15 to 20 degrees in azimuth and you **should have found** the first bird, but did not, go back to due south again and re-check your elevation. If it still checks for proper elevation angle, **nudge** the base on your dish so you modify the north/south line by a couple of degrees (at most). And try again.

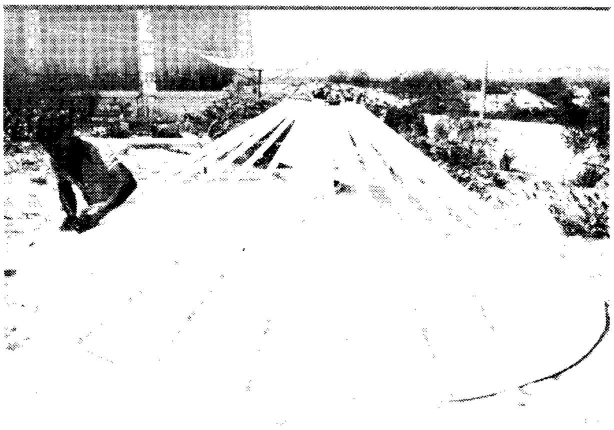
9)With a polar type of mount, if you **align** the polar axis **directly on** north and south, and **if** you have your dish elevation pre-set so that you are pointing into the geostationary orbit belt at **due** south, then you **must find birds** as you turn the dish towards the closest birds to due south. And if you do not? Either you have mis-set the elevation (remember that depending upon how and where you place your inclinometer you either read the actual elevation angle, or, **the compliment** of that angle; i.e. you read 60 which is the compliment of 30 to equal 90 degrees), or, the dish base is **not** north-south aligned.

When you do find a bird, take a marking pen and mark on something that moves (in and out, sideways, or whatever) as you continue to rotate the dish azimuth. This provides a "return to" mark for re-finding the first bird. Now go to the west (or east) for the **next** closest bird. If it is not where it should be, go back to the first bird found and very carefully adjust the north-south axis one more time just a tad one way or the other. Repeak on the first bird and then go looking for the second again. If it is still not where it should be, return to the first bird and re-trace your north-south axis "just a tad more" by going **back to** the original north - south alignment, and then just a tad in the **opposite** direction. And repeat the peaking, and hunt, for the second bird.

INCLINOMETER is most important tool you will "invest" in; learning how to use it, accurately, is equally important.

Through all of this **do not touch the elevation control**. At all. If it is properly set for you when the dish points to an imaginary bird that is due south of you, it will be properly set for all other birds also. **Provided**, your dish axis is true north by south. If you find a second bird but it is weaker than it should be, and you find you can improve it by increasing (or decreasing) the elevation just a smidgen, that instantly tells you the problem with "peaking" is in a slightly mis-aligned north by south axis.

A DISH WILL TRACK from satellite to satellite ONLY IF it has proper north/south (polar mount) alignment. ADM 11 foot antenna shown.



SYSTEM pictures are very much dependent upon care and skill use to assemble dish reflector surface. If it does not fit properly, easily, find out why. Don't force it - there is a reason why it binds!

You may find that several birds in a row are fine, but as you gradually get further from due south they become weaker. Again, **this indicates a slight mis-alignment in the north south axis.** IF (this may be a big IF) the polar mount is properly designed and installed, all birds will be in a line, from horizon to horizon, without any fine tweeking of the elevation control once it has been set.

Can't you do the same thing with a **bird location** since your computer chart will tell you both the azimuth and the elevation for each bird? Yes, you can. But there is a danger here. It is very possible to find a bird, or even two birds, as you grope with the elevation and azimuth controls. But you will find them at a "slanting angle" or "track" as you cross the sky. And each time you want to move to another bird you will spend a frustrating extended period of time readjusting **both** the azimuth **and** the elevation controls. You could get very lucky and hit the north/south alignment with the dish, and have perfect or near perfect tracking, by starting off with the dish pointing at some known satellite. But the chances are against that happening. South is such an easy direction to find, **and once the elevation is set for south**, that leaves you with only a single adjustment to worry about.

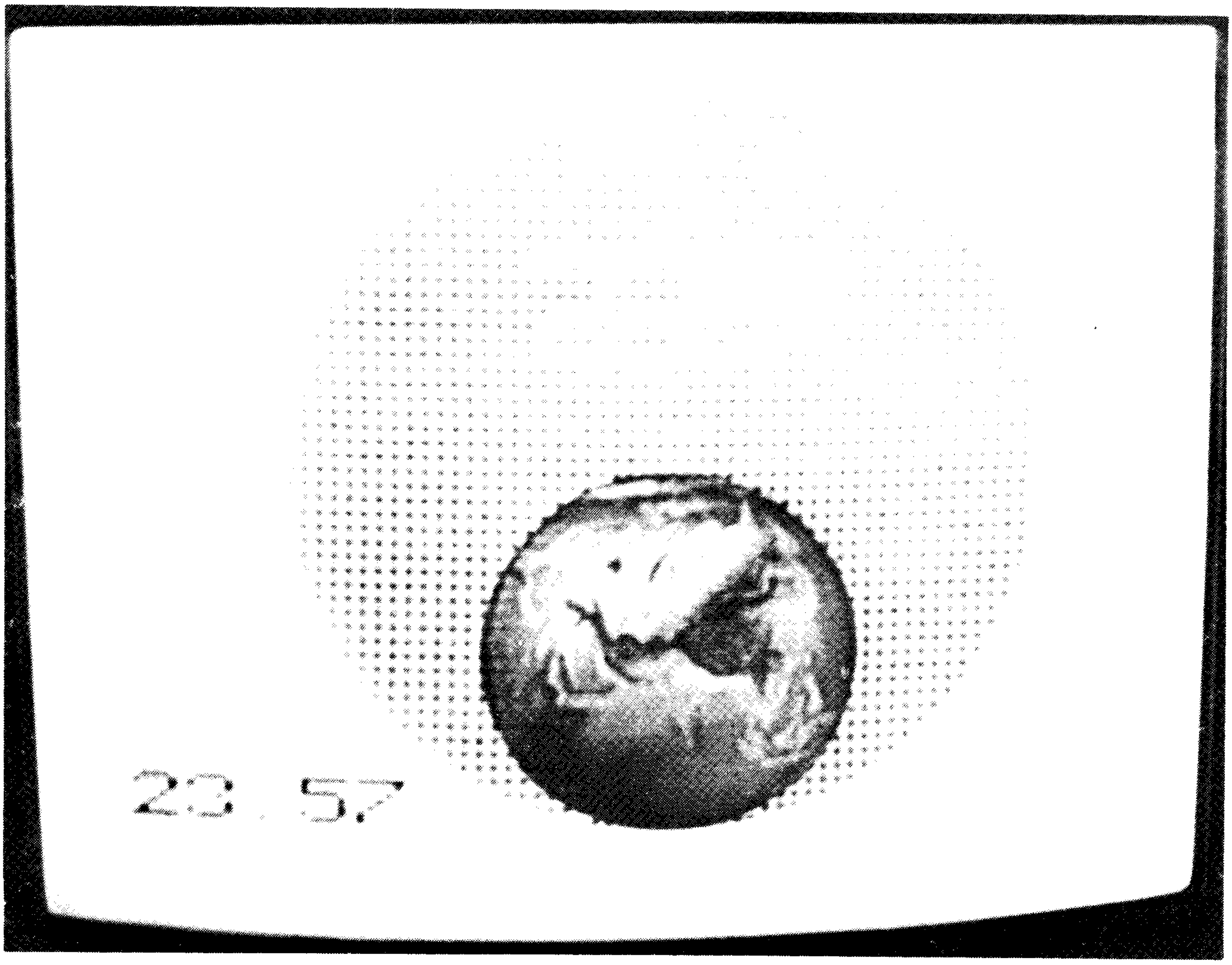
WHEN ALL ELSE FAILS...

use logic. There is ample information in this Manual to get you into and out of most of the major tough spots. For example, if everything seems to check out but you are simply not finding a bird, the problem may well be electronic. The LNA may not be getting power; the connector on the cable may be shorted, or so short as to not be making contact. The feed may be adjusted for vertical and all of the birds you are trying to find are horizontal. Or, as has happened to me several times, you may have a TVRO receiver at the antenna, a monitor hooked to the receiver but there lying on the ground is the downline connector that is supposed to be plugged into the back of the TVRO receiver!

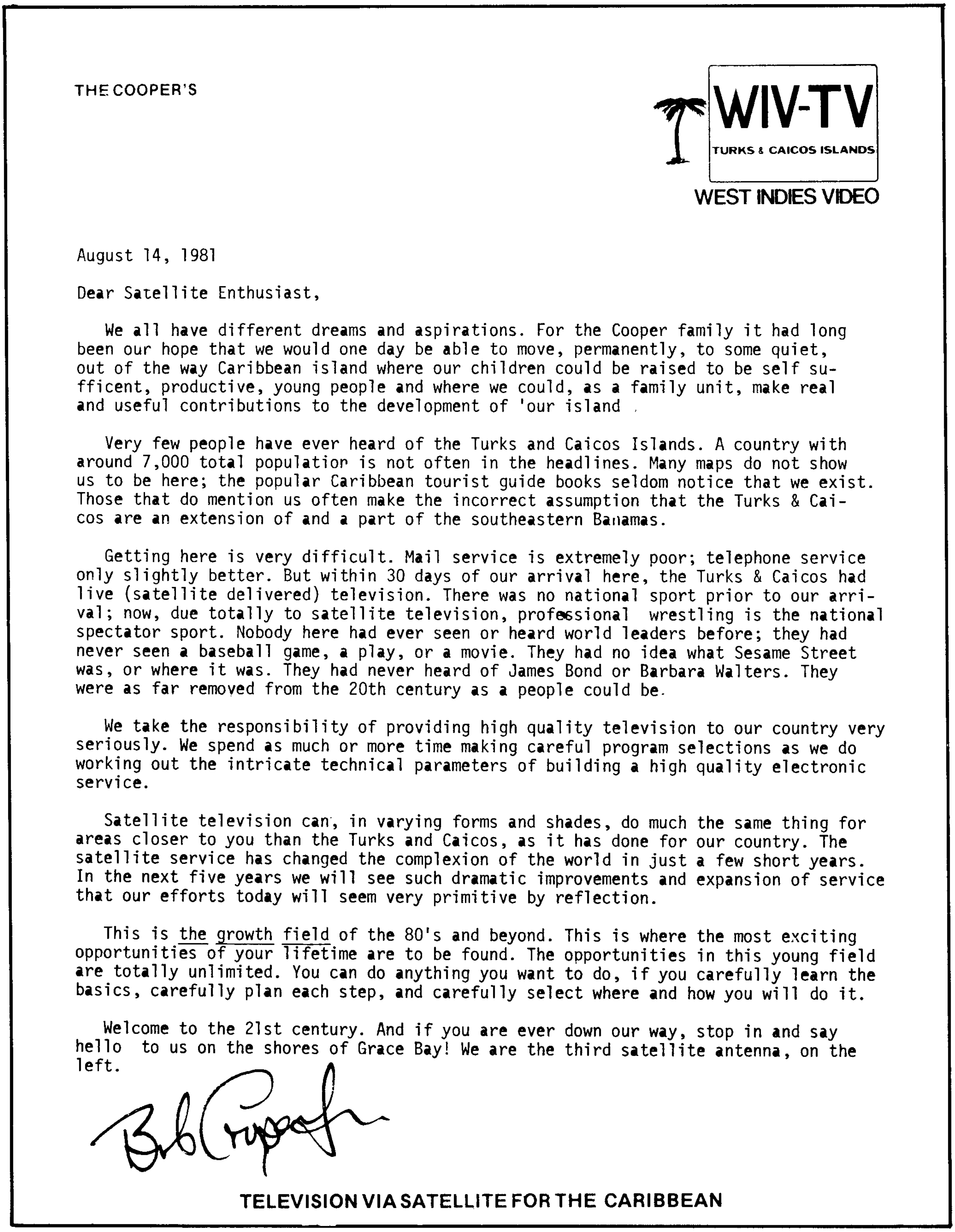
Worst of all is finding it, **and then losing it**. When you find a signal, **stop** everything. Carefully mark on metal surfaces where the antenna adjustments are at that point. **Then proceed** to try to peak up the signal. If it is weak to begin with, you may lose it and then in a moment of frustration get so far away that you cannot find it again.

Happy hunting!

NOTES



THE ULTIMATE PRIZE - Near perfect reception from Russia (Molniya inclined orbit transmission shown here) **on an 1 foot dish private terminal. Reception photo courtesy of Lynn Hurd, Beaverton, Oregon.**



THE COOPER'S

WIV-TV
TURKS & CAICOS ISLANDS
WEST INDIES VIDEO

August 14, 1981

Dear Satellite Enthusiast,

We all have different dreams and aspirations. For the Cooper family it had long been our hope that we would one day be able to move, permanently, to some quiet, out of the way Caribbean island where our children could be raised to be self sufficent, productive, young people and where we could, as a family unit, make real and useful contributions to the development of 'our island.

Very few people have ever heard of the Turks and Caicos Islands. A country with around 7,000 total population is not often in the headlines. Many maps do not show us to be here; the popular Caribbean tourist guide books seldom notice that we exist. Those that do mention us often make the incorrect assumption that the Turks & Caicos are an extension of and a part of the southeastern Bahamas.

Getting here is very difficult. Mail service is extremely poor; telephone service only slightly better. But within 30 days of our arrival here, the Turks & Caicos had live (satellite delivered) television. There was no national sport prior to our arrival; now, due totally to satellite television, professional wrestling is the national spectator sport. Nobody here had ever seen or heard world leaders before; they had never seen a baseball game, a play, or a movie. They had no idea what Sesame Street was, or where it was. They had never heard of James Bond or Barbara Walters. They were as far removed from the 20th century as a people could be.

We take the responsibility of providing high quality television to our country very seriously. We spend as much or more time making careful program selections as we do working out the intricate technical parameters of building a high quality electronic service.

Satellite television can, in varying forms and shades, do much the same thing for areas closer to you than the Turks and Caicos, as it has done for our country. The satellite service has changed the complexion of the world in just a few short years. In the next five years we will see such dramatic improvements and expansion of service that our efforts today will seem very primitive by reflection.

This is the growth field of the 80's and beyond. This is where the most exciting opportunities of your lifetime are to be found. The opportunities in this young field are totally unlimited. You can do anything you want to do, if you carefully learn the basics, carefully plan each step, and carefully select where and how you will do it.

Welcome to the 21st century. And if you are ever down our way, stop in and say hello to us on the shores of Grace Bay! We are the third satellite antenna, on the left.

Bob Cooper

TELEVISION VIA SATELLITE FOR THE CARIBBEAN

NOTES